APPENDIX A

FY 2003 Accounting and Preliminary FY 2004 Budget Planning (prior to final allocations)

Michael Johnson
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FY 2003 Accounting and
Preliminary FY 2004 Budget Planning (prior to final allocations)

Climate Observation Program
Preliminary FY 04 Budget Planning ($ K)

	System total			C&GC		COSP Ocean		COSP Carbon		Lab Base		Other	
Network	**FY03**	**FY04**	**Change**	FY03	FY04	FY03	FY04	FY03	FY04	FY03	FY04	FY03	FY04
Tide Gauges	**710**	**946**	**236**	0	25	0	271	0	0	710	650	0	0
Drifting Buoys	**2077**	**2679**	**602**	756	627	271	1102	0	0	1050	950	0	0
Ships of Opportunity	**1903**	**2452**	**549**	995	773	301	1149	0	0	607	530	0	0
Tropical Moored Buoys	**3175**	**3625**	**450**	600	600	0	450	0	0	2575	2575	0	0
Argo	**275**	**273**	**-2**	275	273	0	0	0	0	0	0	0	0
Ocean Reference Stations	**1943**	**2632**	**689**	1101	0	788	2632	0	0	54	0	0	0
Ocean Carbon Monitoring	**2204**	**2874**	**670**	0	0	1060	1747	1127	1127	0	0	17	0
SURFRAD	**210**	**210**	**0**	210	105	0	0	0	0	0	0	0	105
Rain Gauges	**139**	**179**	**40**	139	149	0	0	0	0	0	0	0	30
Dedicated Ship Time	**626**	**617**	**-9**	0	150							626	467
Data & Assimilation Subsystems	**1017**	**1455**	**438**	464	578	70	203	0	0	393	674	90	0
Management & Product Delivery	**853**	**1398**	**545**	438	886	110	197	0	0	305	315	0	0
Overhead - Admin Services	**187**	**729**	**542**	187	729 *	0	0	0	0	0	0	0	0
	15319	**20069**	**4750**	5165	4895	2600	7751	1127	1127	5694	5694	733	602

Notes:
*The FY04 C&GC value for "Overhead" is the 5% administrative fee for processing all non-C&GC funding. This supports salaries, office space, supplies, etc.
The "Other" column is partnerships with other programs.
In FY03 GCC paid $17 K to augment the pCO2 project; Master paid $90 K for OCO database management.
In FY04 COSP will pay $105 K in the phase-out of SURFRAD from ocean to atmospheric obs; GCOS will pay $30 K partnership in Pacific rain gauges.

APPENDIX B

Program Plan for Building a Sustained Ocean Observing System for Climate

Michael Johnson
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Program Plan
For
Building a Sustained Ocean Observing System for Climate

Updated: March 2004

Overall Summary

The Climate Change Science Program (CCSP) has identified the critical need for the federal government to begin delivering regular reports documenting the present state of the climate system components. Yet an observing system does not presently exist that is capable of accurately documenting climate variability and change in the Earth's oceans, atmosphere, cryosphere, and land surface. Through this program plan NOAA will develop the infrastructure necessary to build, with national and international partners, the ocean component of a global climate observing system and to deliver regular reports on the ocean's contribution to the state of the climate and on the adequacy of the observing system.

1.0 Base Program

1.1 Key activities currently carried out by NOAA for this strategy area: Over the past decade NOAA has worked with national and international partners to begin building a sustained global ocean system for climate, focusing first on the tropical Pacific, expanding to the Atlantic, and promoting future research in the Indian Ocean. It is now well understood that documenting and forecasting climate will require continuous measurements from space along with the instrumenting of the entire global ocean. The present international effort is about 45% of what will ultimately be needed for the global system. NOAA presently maintains approximately 60% of the *in situ* networks and 30% of the space components and is committed to the goal of providing at least 50% of the composite system over the long term.

The existing foundation is comprised of eleven complementary *in situ*, space based, data and assimilation subsystems: 1) Global Tide Gauge Network; 2) Global Surface Drifting Buoy Array; 3) Global Ships of Opportunity Network; 4) Tropical Moored Buoy Network; 5) Argo Profiling Float Array; 6) Ocean Reference Stations; 7) Coastal Moorings; 8) Ocean Carbon Monitoring Network; 9) Dedicated Ship Operations; 10) Satellites for Sea Surface Temperature, Sea Surface Height, Surface Vector Winds, and Ocean Color; 11) Data and Assimilation Systems and their products (the Global Ocean Data Assimilation Experiment – GODAE). The system design is illustrated in Figure 1. This is an international effort. NOAA's plan includes a twelfth element – 12) System Management and Product Delivery – to focus program resources on answering the nation's highest priority policy - and economically-relevant questions. In addition, complementary atmospheric observations and analyses, including precipitation and radiation, as well as a global analysis of winds using satellite and surface data help complete the system.

The plan is being advanced via matrix management within the NOAA Climate Program. Implementation of the in situ networks is through distributed centers of expertise at the NOAA Research laboratories, the National Ocean Service Center for Operational Oceanographic Products and Services, the National Data Buoy Center, and the university laboratories that have developed the instruments and techniques. The space components are centered in the National Environmental Satellite, Data and Information Service; the space components are being advanced via other NOAA program planning; they are noted here because of their central role in global observation but they are not detailed in this plan. The focal point for developing global ocean data assimilation capabilities will be the Geophysical Fluid Dynamics Laboratory in partnership with the National Centers for Environmental Prediction and university-based applied research centers. The system management functions are focused in the Office of Global Programs.

1.2 Matrix document showing key activities and current status: Illustrated in Figure 2 and detailed below in Section 6.

1.3 Current out-year performance measures based on current funding levels: The performance measures are given in Section 5. At current funding levels the out-year accomplishments will be frozen at the deliverables indicated for FY05.

1.4 Current budget for each of the major activities (FY 2004):

Tide Gauge Network	$1.7 M
Drifting Buoy Array	$2.8 M
Tropical Moored Buoy Network	$4.2 M
Ships-of-Opportunity Network	$4.1 M
Argo Array of Profiling Floats	$10.9 M
Ocean Reference Stations	$3.8 M
Ocean Carbon Monitoring	$2.9 M
Integrated Arctic Observing System	$2.6 M
Dedicated Ship Time	$10.7 M
Data and Assimilation Subsystems	$4.6 M
Management and Product Delivery	$2.4 M
	$50.7 M

2.0 Statement of Need

The *Second Report on the Adequacy of the Global Observing System for Climate in Support of the UNFCCC* concludes "there has been progress and improvement in the implementation of global climate observing systems since the first report, especially in the use of satellite information and in the provision of some ocean observations. At the same time, the Report notes that the global terrestrial networks remain to be fully implemented; the ocean networks lack global coverage and commitment to sustained operations; and the atmospheric networks are not operating with the required global coverage and quality. The Report concludes, in agreement with the IPCC, that there remain serious deficiencies in the ability of the current global observing systems for climate to meet the observational needs of the UNFCCC. …Without urgent action to address these findings, the Parties will lack the information necessary to effectively plan for and manage their response to climate change."

The Report goes on to note "new technology developed and proven by the ocean climate programs of the 1990s has allowed the ocean community to design and commence implementation of an initial ocean climate observing system that is well focused on the UNFCCC needs. The first priority is the full implementation of this system together with its associated data, analysis and product capabilities."

This program plan is founded on the international design noted in the Report; it is illustrated in Figure 1. Other requirement drivers include the CCSP Strategic Plan expressing need for "complete global coverage of the oceans with moored, drifting, and ship-based networks," and the OCEAN.US *Implementation of the Initial U.S. IOOS* specifying "the highest priority for the global component of the IOOS is sustained, global coverage." NOAA's contribution to the commencement of global implementation is represented in the current program budget and the progress to date is illustrated in Figure 2. Implementation of this program plan will demonstrate to the world community that the United States is intent on taking immediate action to address the Report findings, is willing to play a leadership role in achieving global coverage of the ocean networks, and is committed to sustained operations.

2.1 Program Office requirements to be met: The NOAA Office of Global Programs is organized around four strategic objectives: 1) Development of an Earth System Model for climate change projections at GFDL; 2) Improvement of NWS operational seasonal to international climate forecasts; 3) Development of the in situ ocean component of the global climate observing system; and 4) Development of decision support tools. This plan describes the program for meeting the third objective.

2.2 Input from NOAA leadership, internal councils, and crosscut teams related to this strategy: VADM Lautenbacher has announced as one of his top priorities the building of a global climate observing system, particularly the ocean component. The NOAA Council on Long Term Climate Monitoring (CLTCM) has prioritized elements of ocean observation for their feasibility, impact and timeliness for reducing uncertainty in the role of the ocean in climate variability and change. A cross-cut team has been established in response to the recommendations of the NOAA Performance Review for developing an observing system architecture that will a) determine the adequacy of the state of the system today and in the future; b) address utilization of the data and archival; and c) consider other systems as well. This program plan is directed toward achieving VADM Lautenbacher's vision, the priorities of the CLTCM, and the three aspects of the observing system architecture for ocean climate.

2.3 External constituent input related to the strategy area: In 2001 the U.S. GOOS Steering Committee conducted a formal review of the 2001 version of this program plan. The review panel included international representatives of the IOC, IGOS, CLIVAR, WOCE, OOPC, GODAE, and JCOMM as well as partner agencies within the United States – NASA and NAVOCEANO. The seven summary recommendations of the review are paraphrased below.

1. Strong overall support for the plan. U.S. GOOS urged NOAA to implement the plan with the following additional recommendations:
2. The need for a management plan – An effort of the proposed magnitude must be integrated, organized, and managed as a system in order to be effective. The management plan should define an orderly decision making process with management accountability that is understood by other agencies and by customers. A single NOAA point of responsibility and authority is very desirable. Sections 7.0–7.7 achieve this recommendation.
3. The need for a data and information management budget. Section 6.12 achieves this recommendation.
4. The need for improved ocean products – evaluation and delivery. Section 7.6 achieves this recommendation.
5. The need for transition to operations of precision altimetry. Section 6.11 achieves this recommendation.
6. The need for ocean carbon monitoring to be better defined. Section 6.8 achieves this recommendation.
7. The need to deal with dedicated ship time issues. Section 6.10 has been revised to achieve this recommendation.

2.4 Relevant Congressional input or guidance related to the strategy area: The FY03 Senate Committee on Appropriations Report "reaffirms its support for the establishment of an integrated, interagency ocean and coastal observing system … and requests the submission of a plan to implement such a system." The National Oceanographic

Partnership Program's Ocean.US office is responding to this Congressional request on behalf of the contributing agencies. The climate system detailed below forms the nucleus of the global component of the U.S. Integrated Ocean Observing System.

2.5 Known impediments (legal, fiscal, policy) towards achieving performance targets and objectives: None.

3.0 Program Initiative

3.1 Overall strategy for addressing deficiencies outlined in the Statement of Need Section. The strategic approach underlying this program plan is as follows:

- Build the long-term ocean component of the observing system in the context of a comprehensive, multi-year, climate services initiative. Improved marine and coastal forecast services will be immediate byproducts.
- Set a 2000-2010 timeline for phased implementation.
- Establish accountability by defining specific objectives and performance measures.
- Define an "initial observing system design" that will accomplish the objectives and performance measures. Identify annual milestones to complete the initial system over the ten-year time line. Emphasize that the initial design is our best guess at this time – it must be evolutionary as knowledge and technology advance.
- State the obvious – a global observing system cannot be built with existing budgets. Estimate the annual funding needed to achieve the identified milestones. Estimate that NOAA will implement about 50% of the global system.
- Work with national and international partners to achieve 100%.

Although NOAA's marine and coastal services and the mission services of the other agencies and nations will benefit from this plan, and are considered throughout, accomplishing NOAA's climate mission is the fundamental driver. The scientific foundations come from the Climate Variability and Predictability Program (CLIVAR), the Carbon Cycle Science Program, and the Global Water Cycle Program. It is not the intent of the plan to provide all of the observations needed by these programs but to provide a baseline observing system, to be sustained over the long term, that can be built upon where needed to answer specific questions. This baseline system looks for efficiencies to be gained by utilizing common platforms/sites/data infrastructure for several objectives in parallel, and seeks to foster a system approach to effective international organization of complementary in situ, satellite, data, and modeling components of climate observation.

Priorities for implementation are now in place based on the concept of extending the building blocks that have already been put in place, and on the international plan drafted by over 300 scientists from 26 nations that met in Saint Raphael, France, October 1999, at the OCEANOBS 99 Conference for design of *The Ocean Observing System for Climate*. Again, this NOAA plan does not seek to implement all aspects of the Saint-Raphael system, but only those base-line components needed to meet the design objectives (see Section 4.2), and those for which NOAA should expect to have primary mission responsibility in the United States.

3.1.1 NOAA context*:* This plan supports NOAA's strategic goal to monitor and observe: "NOAA will invest in needed climate quality observations and encourage other national and international investments to provide a comprehensive observing system in support of climate assessments and forecasts." The plan details how NOAA will achieve one element of that strategic goal – implementation of the sustained *in situ* ocean component of the climate observing system.

3.1.2 Interagency context: The observational objectives of NOAA's climate program and those of the CCSP are essentially identical and the ocean observing system architecture detailed below will be implemented by NOAA within the framework of, and as an element of, the CCSP. At the same time the observing system must be advanced in support of climate services, it must also be advanced in response to a national demand for the ocean agencies to coordinate implementation of an U.S. contribution to the global ocean observing system. It is recognized that an effective global ocean observing system can be achieved only through continuing interaction among all national (and international) partners. In this context, NOAA will provide a significant contribution to the global component of the Integrated Ocean Observing System. Implementation will be coordinated with the National Oceanographic Partnership Program agencies, just as all of NOAA's climate observation and research activities have been coordinated through the U.S. Global Change Research Program for the past decade.

3.1.3 International context: The observational component of climate services has by far the greatest opportunity and necessity for international collaboration. A global observing system by definition crosses international boundaries and the potential exists for both benefits and responsibilities to be shared by many nations. The system described below is based on the international design of, and is an U.S. contribution to, *The Ocean Observing System for Climate* (Saint-Raphael, France, 1999). The observing system projects that make up the climate component have been developed, and will continued to be evolved, organized and managed, in cooperation with the international implementation panels of the Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology (JCOMM), and with scientific guidance from the GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC).

3.2 Proposed out-year performance targets: See Sections 5.0-5.4.

3.3 Discussion of individual investments necessary to address shortfalls: Given in Sections 6.0-7.7.

3.4 ROM cost and schedule for each investment: Details given in Table 2. Summary:

	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
System annual operating cost ($ M)	35.2	41.2	59.2	98.1	125.7	139.3	142.6	144.5

4.0 Program Goal and Objectives

4.1 Goal

The goal of this plan is to build and sustain the ocean component of a global climate observing system that will respond to the long-term observational requirements of the operational forecast centers, international research programs, and major scientific assessments.

4.2 Objectives

The ocean is the memory of the climate system and is second only to the sun in effecting variability in the seasons and long-term climate change. It is estimated that the ocean stores 1000 times more heat than the atmosphere, and 50 times more carbon. Eighty percent of the precipitation that waters our Earth comes directly from the ocean. Changing sea level is one of the most immediate impacts of climate change. Additionally, the key to possible abrupt climate change may lie in deep ocean circulation.

Accordingly, the objectives of the sustained ocean observing system for climate are to:

1) Document long-term trends in sea level change;
2) Document ocean carbon sources and sinks;
3) Document heat uptake, transport, and release by the ocean; and
4) Document the air-sea exchange of water and the ocean's overturning circulation.

This implementation plan will provide a composite global ocean observing system of complementary networks that includes: 1) deployment and maintenance of observational platforms and sensors; 2) data delivery and management; and 3) routine delivery of ocean analyses. This end-to-end ocean system will provide the critical "up-front" information needed for climate forecasting, research, and assessments – continuous, long term, climate quality, global data sets and a suite of routinely delivered ocean analyses. At the same time, the system will provide real-time data to serve the needs of NOAA's marine and coastal forecast missions and the needs of the other agencies in accomplishing their missions.

5.0 Performance Measures

In order to achieve the four objectives, the system must accurately measure: 1) sea level to identify changes resulting from climate variability; 2) ocean carbon content every ten years and the air-sea exchange seasonally; 3) sea surface temperature and surface circulation to identify significant patterns of climate variability; 4) sea surface pressure and air-sea exchanges of heat, momentum, and fresh water to identify changes in forcing functions driving ocean conditions and atmospheric conditions; 5) ocean heat and fresh water content and transports to identify where anomalies enter the ocean, how they move and are transformed, and where they re-emerge to interacting with the atmosphere; 6) identify the essential aspects of thermohaline circulation as well as the subsurface expressions of the patterns of climate variability; and 7) sea ice thickness and concentrations.

The sampling requirements for these parameters have been documented by international GOOS and GCOS. Table 1 lists the requirements as presented at the OCEANOBS 99 Conference in Saint-Raphael, France. It represents the best estimates of the international community at this time.

The Proceedings of OCEANOBS 99 and the final report from the conference, *Observing the Ocean in the 21st Century*, outline implementation strategies for achieving these sampling requirements. Additionally, for documenting sea level variability and change, the implementation strategy is further defined in the *International Sea Level Workshop Report*, 1998; and for documenting ocean carbon sources and sinks the implementation strategy is defined in the *Large Scale CO_2 Observing Plan: In Situ Oceans and Atmosphere (LSCOP)*, 2002. The latter plan is for the United States only at this time, but was developed by U.S. scientists working in collaboration with international partners. The international community met in Paris, January 2003, to advance international implementation of the ocean carbon monitoring system and the United States contribution will be updated as the international plan is formulated. These foundation documents are available from the NOAA Office of Global Programs and are listed in Appendix A.

Based on the requirements in Table 1 and the implementation strategies defined in the foundation documents listed in Appendix A, the system's effectiveness in meeting the objectives will be gauged by the performance metrics listed below. Detailed metrics are given for each objective in sections 5.1-5.4. Those detailed metrics will lead to a system that can be summarized in three overarching measures of success:

Performance Measure 1: Reduce the uncertainty in projections of sea level rise during the 21st century.

Metric: Range between credible estimates of sea level rise (centimeters):

2002	2003	2004	2005	2006	2007	2008	2009	2010
80 cm	80 cm	70 cm	60 cm	50 cm	40 cm	30 cm	25 cm	25 cm

Performance Measure 2: Reduce the uncertainty in estimates of the increase in carbon inventory in the global ocean.

Metric: Uncertainty in estimates of anthropogenic changer per decade (Gigatons):

2002	2003	2004	2005	2006	2007	2008	2009	2010
10 Gt	10 Gt	10 Gt	8 Gt	8 Gt	7 Gt	6 Gt	4 Gt	4 Gt

Performance Measure 3: Reduce the error in global measurement of sea surface temperature.

Metric: Potential satellite bias error (degrees Celsius):

2002	2003	2004	2005	2006	2007	2008	2009	2010
0.7 C	0.7 C	0.6 C	0.5 C	0.4 C	0.3 C	0.2 C	0.2 C	0.2 C

5.1 Document long-term trends in sea level change.

Performance Measure 4: Complete the installation of real-time, remote reporting tide gauges and co-located permanent GPS receivers at the international GLOSS subset of 62 stations for Long Term Trends and subset of 30 stations for altimeter drift calibration.

Performance Measure 5: Establish the permanent infrastructure necessary to process and analyze the tide gauge and GPS data and deliver routine annual sea level change reports.

Metrics:

- For 62 climate reference stations worldwide, routinely deliver an annual report of the variations in relative annual mean sea level for the entire length of the instrumental record, and the monthly mean sea level trend for the past 100 years with 95% confidence interval.
- Routinely deliver an annual report of global absolute sea level change to an accuracy of 1 mm per year.

5.2 Document ocean carbon sources and sinks.

Performance Measure 6: Complete the Northern Hemisphere ocean observing system to assist in determining carbon dioxide sources and sinks over the coterminous United States in partnership with the atmospheric observing system.

Performance Measure 7: Complete the expansion of the global oceanic observing system to inventory global scale oceanic uptake of excess carbon dioxide in partnership with the atmospheric observing system.

Metrics:

- Report interhemispheric gradients of CO_2 constrained to 1 ppm on seasonal time scales.
- Improve measurements of North Atlantic and North Pacific Ocean basin carbon dioxide fluxes to within ±0.2 Pg/C per year.
- Reduce uncertainty on regional estimates of carbon sources and sinks on a global basis to ±50%.

- Report the change in ocean carbon inventory over the last decade constrained to 2 Pg/C per year.
- Provide publicly available, routine changes in inventory of carbon, heat, and salinity in the ocean basins on a decadal time frame to assess the effect of global change and feedbacks on the ocean

5.3 Document the ocean's storage and global transport of heat and fresh water.

Performance Measure 8: For the global ocean, complete the ocean observing system needed to measure the global variations in sea surface temperature, surface and 2000 m circulation, total heat content of the ocean, and the transport of heat across and between all ocean basins.

Performance Measure 9: Design, deploy, and implement instrument and analysis systems to provide long term integrated measures of the global thermohaline circulation and deliver yearly estimates of the state of the thermohaline circulation - intensity, properties, freshwater transport.

Metrics:

- At ocean reference stations, deliver routine annual analyses of variability in average temperature at 0-1000 m depth to 0.1°C, and seasonal average temperature change to 0.1°C per three months.
- Deliver analyses of the seasonal means of the surface and 2000 m ocean velocity fields on appropriate spatial resolutions that capture the major features of the overturning circulation for all the core climate variability regions (the global tropics, Pacific Decadal Oscillation, North Atlantic Oscillation, high latitude water mass formation regions both northern and southern hemispheres).
- Deliver analyses of monthly mean sea surface temperature anomaly at 500 km resolution to 0.2°C accuracy, average temperature at 0-1000 m depth to 0.5°C accuracy, and annual average temperature change to 0.5°C per year.
- For the sinking regions of the north Atlantic and southern hemisphere, deliver yearly estimates of the annual average temperature and salinity of the intermediate, deep, and bottom waters to 0.03°C and 0.03PSU.
- Across zonal sections in the Atlantic at 24°N, 47°N, and globally at 35°S, deliver estimates of the average annual meridional heat transport from surface to bottom at 0.3PWatt accuracy.

5.3 Document the air-sea exchange of heat and fresh water.

Performance Measure 10: For the global tropical ocean belt, complete the upper ocean and surface meteorology observing system needed to measure the ocean-atmosphere exchange of heat.

Performance Measure 11: For the global ocean, complete the oceanographic, surface meteorology, and analysis system needed to measure variability in the ocean-atmosphere exchange of fresh water, i.e., precipitation and evaporation.

Metrics:

- For the global ocean, deliver analyses of weekly mean sea surface temperature at 500 km resolution to 0.2°C accuracy
- At ocean reference stations, deliver routine annual analyses of variability in ocean-atmosphere flux to 10 W/m^2.

- For the global ocean deliver weekly analysis of precipitation and evaporation at 500 km resolution to 5 cm per month accuracy.

6.0 Milestones

In order to achieve the Performance Measures, the integrated ocean observing system will be completed according to the following schedule. The schedule is based on the initial design and projections of adequate funding. The milestones will be updated annually to reflect evolution of the design as knowledge and technology advance, and to reflect the realities of funding availability.

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
System % Complete:	40	45	48	55	77	88	94	99	100

Although individual network priorities are described below, they must all go forward together as a system. For example, the global Argo array of profiling floats is a primary tool for documenting ocean heat content; yet deployment of the floats in the far corners of the ocean cannot be achieved without the ships-of-opportunity and dedicated ship time elements; and the Argo array cannot do its work without global over-flight by continued precision altimeter space missions; while the measurements taken by all networks will be rendered effective only through the data and assimilation subsystems.

The following sections indicate network improvements that work toward building the observing system as a whole. The ocean observing system is a composite of complementary networks, each one contributing its unique strengths; most serve multiple purposes. One of the primary goals of NOAA's Office of Climate Observation is to look for efficiencies to be gained by utilizing common platforms/sites/data infrastructure for several objectives in parallel. For these reasons it is difficult to assign the network components specifically to the climate service product lines on a one-to-one basis. In general, however, the network tasks described below will contribute to the deliverables as follows:

1) Document long-term trends in sea level change:
   - Tide Gauge Network
   - Satellites
   - Data and Assimilation Subsystems

2) Document ocean carbon sources and sinks:
   - Drifting Buoy Array
   - Tropical Moored Buoy Network
   - Ships of Opportunity
   - Argo Array
   - Ocean Reference Stations
   - Ocean Carbon Measurements
   - Coastal Moorings
   - Dedicated Ship Time
   - Data and Assimilation Subsystems

3) Document heat uptake, transport, and release by the ocean:
   - Tide Gauge Network
   - Drifting Buoy Array
   - Tropical Moored Buoy Network
   - Ships of Opportunity
   - Argo Array
   - Ocean Reference Stations

- Coastal Moorings
- Dedicated Ship Time
- Satellites
- Data and Assimilation Subsystems

4) Document the air-sea exchange of water and the ocean's overturning circulation:
- Drifting Buoy Array
- Tropical Moored Buoy Network
- Ships of Opportunity
- Argo Array
- Ocean Reference Stations
- Coastal Moorings
- Dedicated Ship Time
- Satellites
- Data and Assimilation Subsystems

Priorities and milestones for the individual networks follow. For each network the several priority tasks are listed in tabular form. The bottom lines of the tables give the representative milestones that are shown graphically in Figure 2; representative milestones are used to simplify the graphic depiction of the phased implementation plan illustrated by Figure 2. Relative emphases in completing the several components of the observing system will depend on the relative priorities assigned to the network tasks in the context of the overall requirements of climate services.

6.1 Tide Gauge Network: Tide gauges are necessary for accurately measuring long-term trends in sea level change and for calibration and validation of the measurements from satellite altimeters, which are assimilated into global climate models for predicting climate variability. Many tide stations need to be upgraded with modern technology. Permanent GPS receivers will be installed at a selected subset of stations, leading to a geocentrically located subset expansion from the present 37 GPS sites to 86 sites globally by 2006. In cooperation with international partners NOAA will maintain a global climate network of 199 tide gauges stations, including the subset noted above, for validation of satellite retrievals, validation of climate model results, and documentation of seasonal to centennial variability in the El Nino Southern Oscillation, Indian Ocean and Asian-Australian monsoons, tropical Atlantic variability, North Atlantic Oscillation, North Pacific variability, high latitude circulation, western boundary currents, and circulation through narrow straits and chokepoints. This task will contribute to climate services by providing the long term records needed to 1) document sea level change: 2) document heat uptake, transport, and release by the ocean (sea surface height contributes to the measurement of ocean heat content); and 3) documents the ocean's overturning circulation (gradients of sea surface height across straights and choke-points are used to calculate large-scale ocean currents).

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Operational stations	57	63	63	63	63	63	63	63	107
Research stations	6	0	0	0	0	0	0	0	0
Station upgrades	0	4	10	16	26	32	32	32	199
GPS installation	5	10	14	20	40	40	40	40	86
GPS data processing			X	X	X	X	X	X	X
Technology development				X	X	X	X	X	X
International GPS/DORIS	43	55	75	86	86	86	86	86	86

6.2 Drifting Buoy Array: Data sparse regions of the global ocean are a major source of uncertainty in the seasonal forecasts and are also a major uncertainty in the detection of long-term trends in global sea surface temperature, which in turn is an indicator of global change. Data gaps must be filled by surface drifting buoys to reduce these sources of error to acceptable limits. NOAA, together with international partners, will extend the global SST/velocity drifting buoy array to data sparse regions, increasing from 787 to 1250 buoys by 2005, while adding wind, pressure, and precipitation measurement capabilities to serve short term forecasting as well as climate research, seasonal forecasting, and assessment of long term trends. This task will support climate services by providing measurements needed to 1) document heat uptake, transport, and release by the ocean; 2) document ocean carbon sources and sinks (sea surface temperature affects the rate of transfer of CO_2 between the ocean and atmosphere; 3) document the air-sea exchange of water and the ocean's overturning circulation, and 4) document sea level change by providing the sea surface atmospheric pressure measurements that are essential for calculating sea surface height from satellite altimeter measurements.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Operational buoys	420	670	1040	1040	1040	1040	1040	1040	1250
Research buoys	200	200	0	0	0	0	0	0	0
Add met sensors	40	40	500	670	670	670	670	670	1250
Technology development			X	X	X	X	X	X	X
International array size	787	1050	1250	1250	1250	1250	1250	1250	1250

6.3 Tropical Moored Buoy Network: Most of the heat from the sun enters the ocean in the tropical/sub-tropical belt. The advanced understanding of the role of the tropics in forcing mid-latitude weather and climate was learned primarily through the observations of the tropical moored buoy array (TAO/TRITON) in the Pacific. A similar pilot array in the Atlantic basin (PIRATA) now offers the potential of even better understanding, improved forecasts, and improved ability to discern the causes of longer-term changes in the Oceans. In addition to monitoring the air-sea exchange of heat, the moored buoys provide platforms for supporting instrumentation to measure carbon dioxide and rainfall in the tropics. The global tropical moored buoy network will be expanded from 79 to 112 stations by 2009 and will ultimately span all three oceans - Pacific, Atlantic, and Indian Ocean. This task will support climate services by providing both ocean and atmospheric observations to 1) document heat uptake, transport, and release by the ocean; 2) document carbon sources and sinks; and 3) document the air-sea exchange of fresh water.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Operational buoys	55	65	65	65	65	65	65	65	79
Research buoys	10	0	0	0	0	0	0	0	0
Indian Ocean expansion			3	6	15	15	15	15	30
Atlantic Ocean expansion			2	2	5	5	5	5	9
Add salinity sensors	10	10	60	65	65	65	65	65	99
Add flux capability to buoys			5	5	5	5	5	5	8
Technology development			X	X	X	X	X	X	X
International network size	79	79	82	85	89	100	112	112	112

6.4 Ships of Opportunity: The global atmospheric and oceanic data from Ships of Opportunity (SOOP) have been the foundation for understanding long-term changes in marine climate and are essential input to climate and weather forecast models. Improved instrument accuracy, automated reporting, and improved information about how the observations were taken will greatly enhance the quality of these data, reducing both systematic and random errors. NOAA will improve meteorological measurement capabilities on the global SOOP fleet for improved marine weather and climate forecasting in general, and will concentrate on a specific subset of high accuracy SOOP lines to be frequently repeated and sampled at high resolution for systematic upper ocean and atmospheric measurement. This climate-specific subset will build from 26 lines presently occupied to a designed global network of 41 lines by 2007 and will provide measurements of the upper ocean thermal structure, sea surface temperature and chemistry, and surface meteorology of high accuracy. Additionally, the SOOP fleet is the primary vehicle for deployment of the drifting arrays. This task will support climate services by providing ocean and atmosphere measurements needed to 1) document heat uptake, transport, and release by the ocean; and 2) document ocean carbon sources and sinks (carbon sampling instrumentation is detailed under a separate task below); and 3) document the air-sea exchange of water and the ocean's overturning circulation.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Operational HRX lines	2	15	21	21	21	21	21	21	26
Research HRX lines	6	0	0	0	0	0	0	0	0
Frequently repeated lines	4	5	8	8	8	8	8	8	22
Add flux/salinity HRX	2	2	7	12	15	15	15	15	26
Auto-met package, VOSClim	0	0	40	100	200	200	200	200	200
Technology development				X	X	X	X	X	X
International lines	26	29	30	36	45	45	45	45	45

6.5 Argo array of profiling floats: The heat content of the upper 2000 meters of the world's oceans, and the transfer of that heat to and from the atmosphere, are variables central to the climate system. The Argo array of profiling floats is designed to provide essential broad-scale, basin-wide monitoring of the upper ocean heat content. Three thousand floats will be deployed worldwide by 2005. The U.S. contribution is approximately one-half of this international project. Glider technology will replace standard drifting Argo floats in the boundary currents and targeted deep circulation regions. This task will support climate services by providing measurements needed to 1) document heat uptake, transport, and release by the ocean; and 2) document the air-sea exchange of water and the ocean's overturning circulation.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Operational Argo floats	320	1000	1500	1485	1485	1385	1385	1385	2800
Research Argo floats	15	0	0	0	0	0	0	0	0
Operational gliders	0	0	0	0	0	100	100	100	200
Research gliders	3	3	10	20	50	0	0	0	0
Technology development				X	X	X	X	X	X
International array size	1000	2000	3000	3000	3000	3000	3000	3000	3000

6.6 Ocean Reference Stations:

6.6.1 Subtask 1: NOAA, together with international partners, will implement a global network of ocean reference station moorings, expanding from the present six pilot stations to a permanent network of 21 (plus 8 within the tropical moored buoy network) by 2008. NSF's Ocean Observatories Initiative will provide a major piece of the infrastructure needed for this network, establishing high-capability re-locatable moored buoys in remote ocean locations. NOAA will maintain climate instrumentation aboard the NSF-supplied platforms.

6.6.2 Subtask 2: Monitoring the transport within the ocean is a central element of documenting the overturning circulation of fresh water and heat and carbon uptake and release; heat and carbon generally are released to the atmosphere in regions of the ocean far distant from where they enter. Long-term monitoring of key choke points, such as the Indonesian through-flow, and of boundary currents along the continents, such as the Gulf Stream, must be established to measure the primary routes of ocean heat, carbon, and fresh water transport.

6.6.3 Subtask 3: Monitoring thermohaline circulation is a central element of documenting the ocean's overturning circulation and a critical need for helping scientists understand the role of the ocean in abrupt climate change. It is essential that the ocean observing system maintain watch at a few control points at critical locations. Key monitoring sites have been identified by an international team of scientists for deployment of long-term subsurface moored arrays and repeated temperature, salinity, and chemical tracer surveys from research vessels. NOAA will focus with Canadian partners on monitoring the Labrador Sea and upstream locations in Davis Strait and the Canadian Arctic Archipelago, while European partners will focus on the eastern north Atlantic. One exception to this is that NOAA will maintain the Greenland-Iceland-Norwegian (GIN) Seas times-series that was started in 1991. Additionally, to estimate the effect of Antarctic zone water on the global thermohaline circulation, NOAA will maintain time series moorings and repeat sections in the northwestern Weddell Sea, and will establish time series measurements in the Ross Sea. These locations are important to examine the variability of water mass transformation processes as they relate to climate variability in the Southern Ocean.

6.6.4 Summary: These three subtasks will support climate services by providing ocean and atmosphere measurements needed to 1) document heat uptake, transport, and release by the ocean; 2) document ocean carbon sources and sinks (carbon sampling instrumentation is detailed under a separate task below; and 3) document the air-sea exchange of water and the ocean's overturning circulation.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Operational flux moorings	1	2	6	7	9	9	9	9	29
Research flux moorings	1	0	0	0	0	0	0	0	0
Operational full depth stations	0	0	3	5	10	10	10	10	42
Research full depth stations	1	1	0	0	0	0	0	0	0
Operational transport stations	0	0	2	4	4	5	5	5	10
Research transport stations	2	0	0	0	0	0	0	0	0
Pacific Raingauge (PACRAIN)	0	28	28	28	28	28	28	28	28
Research rain gauge network	28	0	0	0	0	0	0	0	0
Operational GIN time series	0	1	1	1	1	1	1	1	1
Research GIN time series	1	0	0	0	0	0	0	0	0
Sinking regions, operational	0	2	2	4	4	4	4	4	5

Sinking regions, research	1	1	0	0	0	0	0	0	0
S. Hemisphere sections	0	0	0	2	3	3	3	3	3
Technology development				X	X	X	X	X	X
International flux array	6	7	10	14	16	29	29	29	29

6.7 Coastal Moorings: Improved near shore measurements from moored buoys are critical to coastal forecasting as well as to linking the deep ocean to regional impacts of climate variability. The boundary currents along continental coastlines are major movers of the ocean's heat and fresh water (e.g., the Gulf Stream). Furthermore, the coastal regions are critical to the study of the role of the ocean in the intensification of storms, which are key to the global atmospheric transport of heat, momentum and water, and are a significant impact of climate on society. Coastal arrays are maintained by many nations making this a "global" network of "coastal" stations. A climate subset of NOAA's existing network will be improved by augmenting and upgrading the instrument suite to provide measurements of the upper ocean as well as the sea surface and surface meteorology. Ten of these moorings will serve as platforms-of-opportunity for the addition of carbon sampling instrumentation. This task will support climate services by providing ocean and atmosphere measurements needed to 1) document heat uptake, transport, and release by the ocean; 2) document ocean carbon sources and sinks (carbon sampling instrumentation is detailed under a separate task below); and 3) document the air-sea exchange of water.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Upgrade w/climate sensors	0	0	20	65	65	65	65	65	105
Technology development				X	X	X	X	X	X
International coastal network	0	0	20	85	95	105	105	105	105

6.8 Ocean Carbon: Understanding the global carbon cycle and the accurate measurement of the regional sources and sinks of carbon are of critical importance to international policy decision making as well as to forecasting long term trends in climate. Projections of long-term global climate change are closely linked to assumptions about feedback effects between the atmosphere, the land, and the ocean. To understand how carbon is cycled through the global climate system, ocean measurements are critical. NOAA will add autonomous carbon dioxide sampling to the moored arrays and the VOS fleet to analyze the seasonal variability in carbon exchange between the ocean and atmosphere, and in cooperation with NSF will implement a program of systematic global ocean surveys that will provide a complete carbon inventory once every ten years. This task is coordinated with the Global Carbon Cycle Science program, is dependent on implementation of the ship lines and moored and drifting arrays, and will support climate services by providing measurements to document ocean carbon sources and sinks.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Inventory lines per decade	6	6	11	11	11	11	11	11	25
Time series moorings	2	2	4	6	6	6	6	6	12
Coastal flux moorings	0	0	0	11	11	11	11	11	29
Flux on ships of opportunity	4	7	12	12	12	12	12	12	21
Research flux on moorings	2	0	0	0	0	0	0	0	0

Trans rsch flux moorings to ops	0	2	2	2	2	2	2	2	2
Technology development			X	X	X	X	X	X	X
International flux array	14	17	28	38	48	62	62	62	62

6.9 Integrated Arctic Observing System: To understand the role of the Arctic on global environmental change, the amount of uncertainty in the causes and trajectories of global climate change needs to be reduced. Given the sensitivity of the Arctic environment to climate variability and change, it is in this region that early indications of the future progression of climate change are likely to be first detected.

Ocean Climate Observations in the Arctic Ocean and Northern High Latitude Seas – A program of sustained observations of this area is being conducted through dedicated and shared ship-based cruises and permanent oceanographic moorings, supplemented by acquisition and analysis of historical data sets. The long-term goal is to detect climate-driven physical and ecological change, especially due to changes in sea ice extent and duration, and in ocean density and circulation that together may lead to changes in ocean heat transport, productivity, and food web structure. International collaboration is essential for completing this program, especially with Russia and Canada. In FY2003, one new mooring was deployed in the Northern Bering Sea, a research cruise was conducted to the Chukchi Sea in collaboration with China, planning was initiated for a future Chukchi Sea cruise in collaboration with Russia, sea-glider deployments were initiated in the Labrador Sea, joint US-Canada observations were conducted in Barrow Strait, and efforts begun to discover, obtain and manage historical data sets.

Arctic Sea Ice Observations – Ice-tethered buoys and bottom-mounted moorings are deployed to monitor the drift of Arctic sea ice and to determine its thickness. The long-term goal is to provide an accurate record of changes in sea ice thickness that, together with satellite observations of sea ice extent, can provide an estimate of changes in sea ice volume. This information is critical for improvement of global climate models and development of a regional Arctic climate model. Several ice buoys and two ice thickness stations were deployed in summer 2003.

This task will support climate services by providing ocean and ice measurements needed to document heat uptake, transport, and release by the ocean.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Arctic pathway moorings	0	0	1	2	4	6	8	8	12
Arctic Ocean moorings	0	0	1	2	4	6	7	7	8
ASOF gateway mooring sets	0.5	0.5	1	1	1	1	2	2	5
Automated drifting stations	0	0	1	2	2	2	2	3	3
Ice buoys	10	10	11	20	20	20	20	20	40
Hydrographic stations	0	0	1	4	6	8	9	10	16
Bering Sea moorings	1	1	1	2	4	6	6	6	6
Western boundary sections	0	0	1	1	1	1	1	1	1
Western boundary moorings	0	0	2	2	4	4	4	4	4
Ice buoys and moored stations	10	11	13	23	25	33	43	51	51

6.10 Dedicated Ship Time:

6.10.1 Subtask 1: Climate Ship time within the UNOLS research fleet for deployment of the moored and drifting arrays, and for deep ocean surveys is an essential component of this initiative. The deep ocean cannot be reached by SOOP and Argo; yet quantification of the carbon and heat content of the entire ocean column is needed to solve the climate equations. In addition to providing the survey and deployment platforms for the autonomous arrays, the research fleet will maintain sensor suites on a small core of vessels as the highest quality calibration points for validation of the other system measurements. Annual requirements for ship time are 54 days in addition to the Ka'imimoana for TAO/TRITON maintenance, 74 days for the carbon inventory, 34 days for PIRATA in addition to the French/Brazilian support (see Subtask 2), 47 days for ocean reference stations growing to 120 days, 60 days for deployment of the drifting arrays in remote regions, and 46 days for thermohaline circulation monitoring growing to 172 days.

6.10.2 Subtask 2: The PIRATA array has been maintained by French research vessels, once per year in the east, and the Brazilian navy once per year on the western side of the Atlantic. Two maintenance visits per year to each mooring are necessary to maintain adequate operational data flow, as has been demonstrated in the Pacific with the TAO/TRITON array. The PIRATA consortium (Brazil, France, U.S.A.) has proposed a plan to establish an international ship base in Natal, Brazil, and operate cooperatively a new ship dedicated to Atlantic climate operations. The consortium has proposed that NOAA and French partners cooperate to acquire a new ship, and build the capacity in Brazil to support long-term climate operations. The new ship would support Argo and drifter deployments as well as PIRATA maintenance. The U.S. homeport for the ship, and support base for north Atlantic operations, would be Charleston, SC; Natal would support operations in the tropical and south Atlantic. This is a new concept in international collaboration and capacity building. In 2003, NOAA began feasibility study together with French and Brazilian partners to identify the best long-term solution to this issue. In the mean time, NOAA will begin supplementing the once-per-year French and Brazilian maintenance cruises with a second maintenance cruise using UNOLS or other charter operations (see Subtask 1).

6.10.3 Summary: This task will support climate services by providing multi-use platforms for the ocean and atmosphere measurements needed to 1) document heat uptake, transport, and release by the ocean; 2) document ocean carbon sources and sinks; and 3) document the air-sea exchange of water and the ocean's overturning circulation.

Ship days at sea	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Ka'imimoana	276	276	276	276	276	276	276	276	276
TAO/TRITON additional	54	54	54	54	54	54	54	54	90
PIRATA	0	0	34	34	34	34	34	34	124
Carbon survey	74	74	74	74	74	74	74	74	240
Coastal flux maps	0	0	0	36	40	40	40	40	240
Reference Stations	47	47	47	60	102	120	120	120	480
Deployment of drifting arrays	0	0	0	60	60	60	60	60	100
Thermohaline circulation	46	46	46	46	90	172	172	172	340
Arctic hydrographic sections	0	0	0	60	60	60	60	60	120
NOAA total	497	497	531	700	790	890	890	890	
International fleet	550	610	750	900	1200	1620	1620	1620	1620

6.11 Satellites:

The initial ocean observing system for climate depends on space based global measurements of 1) sea surface temperature, 2) sea surface height, 3) surface vector winds, and 4) ocean color. These satellite contributions are detailed in other NOAA program plans.

6.11.1 Sea surface temperature: Satellite measurements of sea surface temperature are included in NOAA's operational satellite program and the NPOESS program. Satellite data provide high-resolution sea surface temperature data. Both infrared and microwave satellite data are important. Microwave sea surface temperature data have a significant coverage advantage over infrared sea surface temperature data, because microwave data can be retrieved in cloud-covered regions while infrared cannot. However, microwave sea surface temperatures are at a much lower spatial resolution than infrared. In addition microwave sea surface temperatures cannot be obtained within roughly 50 km of land. A combination of both infrared and microwave data are needed because they have different coverage and error properties. Drifting buoy and other *in situ* data are critically important in providing calibration and validation in satellite data as well as providing bias correction of these data. Satellite biases can occur from obit changes, satellite instrument changes and changes in physical assumptions on the physics of the atmosphere (e.g., through the addition of volcanic aerosols). Thus, drifting buoy and other *in situ* data are needed to correct for any of these changes.

6.11.2 Sea surface height: The value of spaced-based altimeter measurements of sea surface height has now been clearly demonstrated by the TOPEX/Poseidon and Jason missions. Changes in sea level during major El Nino events can now be discerned at high resolution and provide realistic model initializations for seasonal climate forecasting. The same data, when calibrated with island tide gauge observations, are also able to monitor the rate of global sea level change with an accuracy of 1 mm per year. The planned NPOESS altimeter will be adequate for shorter term forecasting, but the NPOESS altimeter will not fly in the same orbit as TOPEX/Poseidon and Jason; and for monitoring long-term sea level change, continuation of precision altimeter missions in the TOPEX/Poseidon/Jason orbit is necessary. Jason follow-on altimeter missions (Ocean Surface Topography Mission, OSTM) are necessary to continue the long-term sea level record. NASA and CNES have asked NOAA and EUMETSAT to transition the Jason-class altimeter from research to operations beginning with the OSTM. In FY2006, NOAA will assume primary U.S. responsibility for continuing this international effort. This task will contribute to climate services by providing the long term records needed to 1) document sea level change; 2) document heat uptake, transport, and release by the ocean; and 3) document the ocean's overturning circulation (sea surface height contributes to the measurement of ocean heat and fresh water content and their transport).

6.11.3 Surface vector winds and ocean color: The best methods of sustaining satellite measurement of surface vector winds and ocean color are still a research and development question; over the next five years NOAA, NASA, and NPOESS will weigh the alternatives and determine the long term strategy for maintenance of these elements.

6.12 Data and Assimilation Subsystems:

6.12.1 Subtask 1 – Long Term Stewardship: The value of the observations does not end with their initial use in detecting and forecasting climate variability. The data must be retained and made available for retrospective analyses to understand long-term climate change, and for designing observing system operations and improvements. NOAA's long history and unique expertise in environmental data management will be applied to the ocean observing system. NOAA also will include the vast holdings of historical ocean observations within the context of the integrated environmental data access and archive system. Support will also be provided for a World Ocean Database to incorporate modern data into an integrated profile system.

6.12.2 Subtask 2 – Data Management and Communications: A robust and scalable data management infrastructure is essential to the vision of a sustained ocean observing system. NOAA's ocean climate data element will contribute a global component to the Data Management and Communications System (DMAC) of the U.S. Integrated Ocean Observing System (IOOS) that is being implemented by the National Oceanographic Partnership Program agencies. The DMAC plan integrates data transport, quality control, data assembly, limited product generation, metadata management, data archeology, data archival, data discovery, and administration functions. Uniform access to data will be addressed through the concept of "middleware" connectivity – a common set of standards and protocols that connects all data sources to data users. The middleware approach shields end users from many of the traditional barriers that have been associated with climate data access, including file formats, the distributed location of data, and the large size of some data sets. The preliminary design has been developed by the National Virtual Ocean Data System (NVODS) project.

The nature of IOOS requires the DMAC to be very highly distributed, supporting both large and small data providers at Federal, regional, state, municipal and academic levels. Data assembly centers will be built into the design to add fault-tolerance and increase ease of use. The GODAE server at Navy's Fleet Numerical Modeling Operations Center (FNMOC) in Monterey will provide robust, operational access to aggregated and quality-controlled real-time data streams and will be a primary assembly center for NOAA's real-time global measurements. Delayed-mode data sources will be distributed across many institutions including the Asia-Pacific Research Data Center (APDRC) (part of the International Pacific Research Center (IPRC) at the University of Hawaii) and the NOAA Data Centers. The APDRC will provide data assembly services for delayed-mode observations in a cooperative partnership with the GODAE Server.

The Data Management and Communications component of NOAA's ocean climate observing system must also deliver the information products needed by NOAA scientists and managers for decision support. The products must provide the information needed to monitor the month-by-month effectiveness of the observing system and to diagnose problems. The products should include intelligible scientific graphics and human-readable numeric tables that provide an overview of the integrated system, selectively merging the data from all relevant measurement streams. These information products will be a component of NOAA's contribution to IOOS.

6.12.3 Subtask 3 – Four dimensional data assimilation including GODAE: For climate forecasting, the combined fields from many different networks are used as initial conditions to begin the forecast. These combined fields, or analyses, are also used to document what the ocean and atmosphere are doing at present and what they did in the past, thus providing a record of the changing climate. By routinely comparing models and data, shortcomings in the observing system can be identified and both the models and forecasts can be improved. To utilize effectively the ocean observations, NOAA will expand the current ocean analyses (presently focused on the tropical Pacific) to the global domain and will develop and implement improved assimilation subsystems that can more effectively use the new data types that are being collected. The principal vehicle for developing this capability, involving both national and international communities and producing a variety of marine products in addition to the use of these observations in forecast systems, will be the Global

Ocean Data Assimilation Experiment (GODAE). The global data and ocean product delivery will be operationalized as a contribution to, and continue as a follow-on to, GODAE through the interagency/international server infrastructure being implemented by GODAE for real-time at FNMOC and for delayed mode at the IPRC; NOAA will provide the primary U.S. support to sustain the IPRC server infrastructure over the long term (in cooperation with Japan). In addition to improving initializations for seasonal forecasting at NCEP, NOAA will implement sustained ocean data assimilation activities at GFDL to enable experimental decadal forecasts, provide ocean initial conditions for IPCC type scenarios, monitor ocean heat uptake, monitor the thermohaline circulation for abrupt changes, and develop a capability for monitoring changes in oceanic carbon sources and sinks.

6.12.4 Summary: This task will support climate services by providing the integrating data, synthesis, and analysis infrastructure for the ocean and atmosphere measurements, both *in situ* and space based, needed to: 1) document long-term trends in sea level change; 2) document heat uptake, transport, and release by the ocean; 3) document ocean carbon sources and sinks; and 3) document the air-sea exchange of water and the ocean's overturning circulation.

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
Data set development	X	X	X	X	X	X	X	X	X
World Ocean Database				X	X	X	X	X	X
Standards and protocols				X	X	X	X	X	X
Systems interoperability	X	X	X	X	X	X	X	X	X
Automated monitoring tools	X	X	X	X	X	X	X	X	X
IPRC server	X	X	X	X	X	X	X	X	X
GODAE pilot activities (JIMO)	X	X	X	X	X	X	X	X	X
Operationalize GODAE pilot		X	X	X	X	X	X	X	X
Global initialization for S-I	X	X	X	X	X	X	X	X	X
Experimental decadal forecast		X	X	X	X	X	X	X	X
Conditions for IPCC scenarios		X	X	X	X	X	X	X	X
Monitor ocean heat uptake		X	X	X	X	X	X	X	X
Monitor thermohaline circulation				X	X	X	X	X	X
Monitor carbon sources and sinks	X	X	X	X	X	X	X	X	X
Argos data processing – Drifting Buoy arrays	X	X	X	X	X	X	X	X	X
Argos data processing – Tropical Moored Buoy network	X	X	X	X	X	X	X	X	X
Argos data processing – Ocean Ref stations	X	X	X	X	X	X	X	X	X

7.0 Management Plan – System organization and product delivery

A global effort of the proposed magnitude must be integrated, organized, and managed as a system in order to be effective. Matrix management is NOAA's corporate business practice and standard protocol. This management plan will follow that protocol by capitalizing on the capabilities that presently exist across the agency while building toward the vision of a single composite system.

Implementation of the individual *in situ* networks will continue to be through distributed centers of expertise at the NOAA Research laboratories, the National Ocean Service Center for Operational Oceanographic Products and Services, the National Data Buoy Center, and the university laboratories that have developed the instruments and techniques. The space components and data management will be centered in the National Environmental Satellite Data and Information Service. The focal point for developing global ocean data assimilation capabilities will be the Geophysical Fluid Dynamics Laboratory in partnership with the National Centers for Environmental Prediction and university-based applied research centers.

To weld the distributed efforts together into the single vision, NOAA has established a project Office of Climate Observation (OCO) under the auspices of the NOAA Climate Program. Organizationally the project office is located within the Office of Global Programs (OGP). OGP embodies a global perspective and is experienced in matrix management. One of OGP's four strategic objectives is "development of the *in situ* ocean component of the global climate observing system." Additionally, for the climate observing system institutional mechanisms must be put in place to ensure continuous and close involvement of the research community. Research, operations, and management are inseparable for climate observation and OGP will hard-wire that relationship.

The Director of OGP utilizing the OCO is charged with advancing NOAA's multi-year program plan for *Building a Sustained Ocean Observing System for Climate*. The OCO is a hybrid combining the functions of a traditional program office with the functions of a center for system monitoring, evaluation, integration, and action. The individual network managers will continue to monitor and evaluate the performance of their individual networks, while the OCO will build the capability to monitor and evaluate the performance of the system as a whole, and take action to evolve the *in situ* networks for overall effectiveness and efficiency in meeting climate observation objectives.

The OCO is the management focus for the distributed ocean network operations and, utilizing the NOAA Observing System Architecture, establishes and maintains operational linkages between the networks and NOAA's other *in situ* and satellite elements and the data and modeling activities that are essential components of climate observation. The office provides a central point of contact within NOAA for coordination with the other agencies and nations involved in observing system implementation. The office receives and acts on feedback from the observing system customers - the operational forecast centers, international research programs, and major scientific assessments - and acts on their observational requirements in accordance with the NOAA Requirements-Based Management Process.

7.1 Subtask 1 – System Monitoring: The OCO monitors the status of the globally distributed networks to anticipate gaps and overlaps in their combined capabilities. Real-time reports from all platforms are being centralized so that up-to-date status can be displayed at all times. The office is working to report system statistics and metrics, routinely and on demand.

7.2 Subtask 2 – Evaluation: Expert teams of scientists both internal and external to NOAA will be established to continually evaluate the effectiveness of the networks in meeting the performance measures and the adequacy of the deliverables in meeting the system objectives. The expert teams will evaluate analysis/synthesis products, recommend product improvements, recommend where additional sampling is needed or redundancies are not needed, recommend better utilization of existing and new *in situ* and satellite data, and assess the impacts of proposed changes to the system. Figure 3 shows the draft framework for expert teams for the ocean component of the system. Three teams are at least partially established…the Air-Sea Exchange of Heat And Water "goal" team under the direction of Dick Reynolds (NCDC); the Carbon Sources and Sinks "goal" team under the direction of Richard Feely, Rik Wanninkhof, and others; and the Seasonal Forecasting "mission" team under the direction of ODASI.

7.3 Subtask 3 – Action: System monitoring and evaluation will be useless unless there is responsive action taken to build the system, fix problems, and improve sampling strategies. Decisions must be made to implement the best solutions to conflicting requirements (multiple partners and customers have differing missions and will inevitably have differing requirements), to re-deploy existing resources to best improve the system, to select the highest priorities for system extensions and funding of new ideas, and to agree on quid pro quo with interagency and international partners. The OCO is charged with advancing NOAA's multi-year program plan and with evolving the system for maximum effectiveness and efficiency along the way.

7.4 Subtask 4 – Intra-agency, Interagency, and International Coordination: National and international coordination is essential to success in building the global ocean observing system for climate. The OCO is charged with building the infrastructure necessary to organize NOAA's ocean observing efforts along three axes – 1) climate services, 2) the U.S. Integrated Ocean Observing System, and 3) international implementation.

1) For climate services the ocean observations must be available to be combined with data from the atmospheric networks, land surface networks, and cryosphere networks. The requirements from the three user communities – the forecast centers, research programs, and scientific assessments – must be received and synthesized into common requirements or prioritized if they do not resolve readily.

2) For the U.S. Integrated Ocean Observing System, NOAA's climate system will make a significant contribution to the global component where like data from the various platforms, *in situ* and space-based, must be combined to form complete fields (e.g., sea surface temperature from ships, drifting and moored buoys, and satellites). NOAA's efforts must be combined with the efforts of the other NOPP agencies into a seamless system.

3) For international implementation NOAA must work with the implementation panels of the Joint IOC/WMO Commission for Oceanography and Marine Meteorology (JCOMM) to ensure that consistent standards and formats are used by all participating nations so that data can be easily shared and that consistent quality can be expected from all platforms regardless of their national origin.

In addition to dedicated infrastructure needed for NOAA to operate an office for climate observation, dedicated infrastructure is also needed for operation of the interagency and intergovernmental planning and implementation coordination organizations. These interagency/international organizations rely on funding from the member agencies for their support. NOAA has historically provided a significant portion of the funding needed to maintain the existing international secretariats, science and implementation panels, and capacity building efforts of GOOS, GCOS, and the JCOMM. This funding support has been ad hock and in general from the research programs. As a central component of sustaining the long-term, operational global climate observing system, support for the national/international coordination/implementation infrastructure will be institutionalized via the OCO.

7.5 Subtask 5 – Annual Report on the Ocean's Role in Climate: The organizing framework to bring the multiple elements of the composite ocean observing system together is the routine delivery of an *Annual Report on the State of the Ocean and the Ocean Observing System for Climate*. The National Climate Change Science Program strategic plan has identified the critical need for regular reports documenting the present state of the climate system components. NOAA's Office of Climate Observation will lead the national effort to develop this reporting for the ocean component. The theme of the report is the

CCSP overarching question for guiding climate observations and monitoring- “What is the current state of the climate, how does it compare with the past, and how can observations be improved to better initialize and validate models for prediction or long term projections?”

The annual report synthesizes satellite and *in situ* observations integrated with models and provides the products to decision makers, the science community, and the public. This reporting framework also establishes a formal mechanism for implementing a “user-driven” observing system and for reporting on the system’s performance in meeting the requirements of the operational forecast centers, international research programs, and major scientific assessments. Stakeholders are invited to provide formal recommendations for system improvement and evolution as part of the annual report process.

The annual report contains four chapters:

1) This chapter describes The Role of the Ocean in Climate and includes a description of ENSO, SST, sea ice, and sea level, and the various demands on the system incorporating seasonal, interannual, decadal, and climate change time scales. This chapter sets the context for the report and outlines common themes, including the significance of the global ocean observing system and the demands on the system.

2) The second chapter documents the State of the Ocean. The target audience is decision makers and non-scientists. This chapter will be written by the experts in the field and will be an annually updated climatology of the ocean, placed in historical context, with discussion of the present uncertainties and with pointers to products of greater detail and climate applications.

3) The third chapter documents the State of the Observing System. The target audience is NOAA management. This chapter has two sections:

a) System Progress in meeting milestones is documented by the network managers for their projects and by the OCO for the system in total. Annual statistics and status are given.
b) In the future, overall System Performance will be evaluated by the expert teams and by the users of ocean observations (the operational forecast centers, research programs, and scientific assessments). The stakeholders will be invited annually to give formal feedback to the observing system management and recommend improvements needed in the observations for delivery of climate services.

4) Chapter four recaps the State of the Science. The target audience is scientists. The final chapter of the report contains a bibliography of refereed publications from scientific journals treating the global observation of ocean heat, carbon, fresh water, and sea level change. Each year a selected number of reprints of particularly relevant scientific papers and/or abstracts will be published with the report.

7.6 Subtask 6 – External Review: The execution of this plan will be subject to normal management review in accordance with NOAA’s Requirements-Based Management Process. Additionally, for specific programmatic advice and guidance, the Climate Observing System Council (COSC) has been established to review the program’s contribution to the international Global Climate Observing System and to recommend effective ways for the program to respond to the long-term observational needs of the operational forecast centers, international research programs, and major scientific assessments. The Council is comprised of members both internal and external to NOAA who individually offer their expert advice; the Council is not expected to develop consensus opinions. The term of membership is two years with a renewal option for two additional terms. The Council meets at least annually to:

- Advise the OCO on priorities for sustaining and enhancing components of the global climate observing system.
- Review the accomplishments and future plans of specific program activities.
- Recommend realignment of activities, or entirely new activities, within the program as appropriate to satisfy the evolving requirements for climate observation.
- Bring to the OCO a broad view on national and international climate research and operational activities and their implications.
- Provide coordinating linkages with national and international programs requiring and/or contributing to the implementation of the global climate observing system.
- Advise the OCO on the balance of activities within the program in the context of NOAA's overarching climate service requirements, of other national and international requirements, and of other national and international contributions to the global climate observing system.

7.7 System management and product delivery milestones:

	NOAA Contributions								International Goal
	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	
System Monitoring	X	X	X	X	X	X	X	X	X
System Evaluation:									
Seasonal forecasting		X	X	X	X	X	X		X
Decadal forecasting		X	X	X	X	X	X	X	X
Climate change				X	X	X	X	X	X
Sea level change		X	X	X	X	X	X	X	X
Carbon sources and sinks									X
Air-sea exchange,heat/water		X	X	X	X	X	X	X	X
Heat storage/thermohaline circulation		X	X	X	X	X	X	X	X
SST	X	X	X	X	X	X	X	X	X
Sea Ice		X	X	X	X	X	X	X	X
Interagency/International panels		X	X	X	X	X	X	X	X
International capacity building				X	X	X	X	X	X
Transition SST eval res to ops	X	X	X	X	X	X	X	X	X
Mgmt – wkshps & science mtgs		X	X	X	X	X	X	X	X
Mgmt – administration & finance		X	X	X	X	X	X	X	X
Mmgt ops funded from research	X	X	X	X	X	X	X	X	X
Annual Report		X	X	X	X	X	X	X	X
External review				X	X	X	X	X	X

Table 2. Tabulated Observational Data Requirements for GOOS/GCOS (from GOOS, 1999).

A summary of the sampling requirements for the global ocean, based largely on OOSDP (1995), but with revisions as appropriate. These are a statement of the required measurement network characteristics, not the characteristics of the derived field. The field estimates must factor in geophysical noise and unsampled signal. Some projections (largely unverified) have been included for GODAE.

Sampling Requirements for the Global Ocean							
Code	Application	Variable	Hor. Res.	Vert. Res.	Time Res.	#samples	Accuracy
A	NWP, climate, mesoscale ocean	Remote SST	10 km	-	6 hours	1	0.1-0.3°C
B	Bias correction, trends	*In situ* SST	500 km	-	1 week	25	0.2-0.5°C
C	Climate variability	Sea surface salinity	200 km	-	10 day	1	0.1
D	Climate prediction and variability	Surface wind	2°	-	1-2 day	1-4	0.5-1 m/s in components
E	Mesoscale, coastal	Surface wind	50 km	-	1 day	1	1-2 m/s
F	Climate	Heat flux	2° x 5°	-	month	50	Net: 10 W/m^2
G	Climate	Precip.	2° x 5°	-	daily	Several	5 cm/month
H	Climate change trends	Sea level	30-50 gauges + GPS with altimetry, or several 100 gauges + GPS	-	monthly means		1 cm, giving 0.1 mm/yr accuracy trends over 1-2 decades
I	Climate variability	Sea level anomalies	100-200 km	-	10-30 days	~ 10	2 cm
J	Mesoscale variability	Sea level anomalies	25-50 km	-	2 days	1	2-4 cm
K	Climate, short-range prediction	sea ice extent, concentration	~ 30 km	-	1 day	1	10-30 km 2-5%
L	Climate, short-range prediction	sea ice velocity	~ 200 km	-	Daily	1	~ cm/s
M	Climate	sea ice volume, thickness	500 km	-	monthly	1	~ 30 cm
N	Climate	surface pCO_2	25-100 km	-	daily	1	0.2-0.3 µatm
O	ENSO prediction	T(z)	1.5° x 15°	15 m over 500 m	5 days	4	0.2°C
P	Climate variability	T(z)	1.5° x 5°	~ 5 vertical modes	1 month	1	0.2°C
Q	Mesoscale ocean	T(z)	50 km	~ 5 modes	10 days	1	0.2°C
R	Climate	S(z)	large-scale	~ 30 m	monthly	1	0.01
S	Climate, short-range prediction	U(surface)	600 km	-	month	1	2 cm/s
T	Climate model valid.	U(z)	a few places	30 m	monthly means	30	2 cm/s

5

Table 1. From *The Action Plan for GOOS/GCOS and Sustained Observation for CLIVAR* by Needler et al. -- *OCEANOBS 99*

Appendix A

Foundation Documents

Observing the Oceans in the 21st Century, edited by Chester J. Koblinsky and Neville R. Smith, GODAE Project Office, Bureau of Meteorology, Melbourne, Australia, ISBN 0642 70618 2, 2001.

OCEANOBS 99, proceedings of the International Conference on the Ocean Observing System for Climate, GCOS/GOOS/WCRP Ocean Observations Panel for Climate and the CLIVAR Upper Ocean Panel, Saint-Raphael, France, October 1999.

International Sea Level Workshop Report, GCOS/GOOS/WCRP Ocean Observations Panel for Climate and the CLIVAR Upper Ocean Panel, GCOS #43, GOOS #55, ICPO #16, April 1998.

A Large Scale CO_2 Observing Plan: In Situ Oceans and Atmosphere (LSCOP), a contribution to the implementation of the U.S. Carbon Cycle Science Plan by the *In Situ* Large-Scale CO_2 Observations Working Group, April 2002.

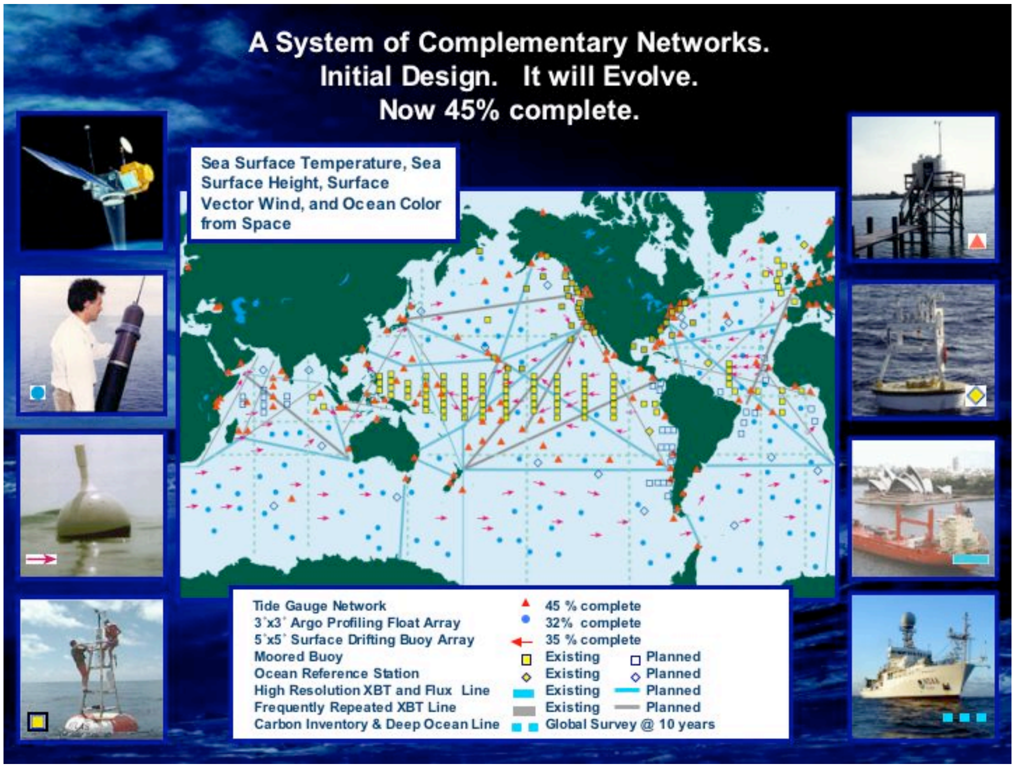

Figure 1

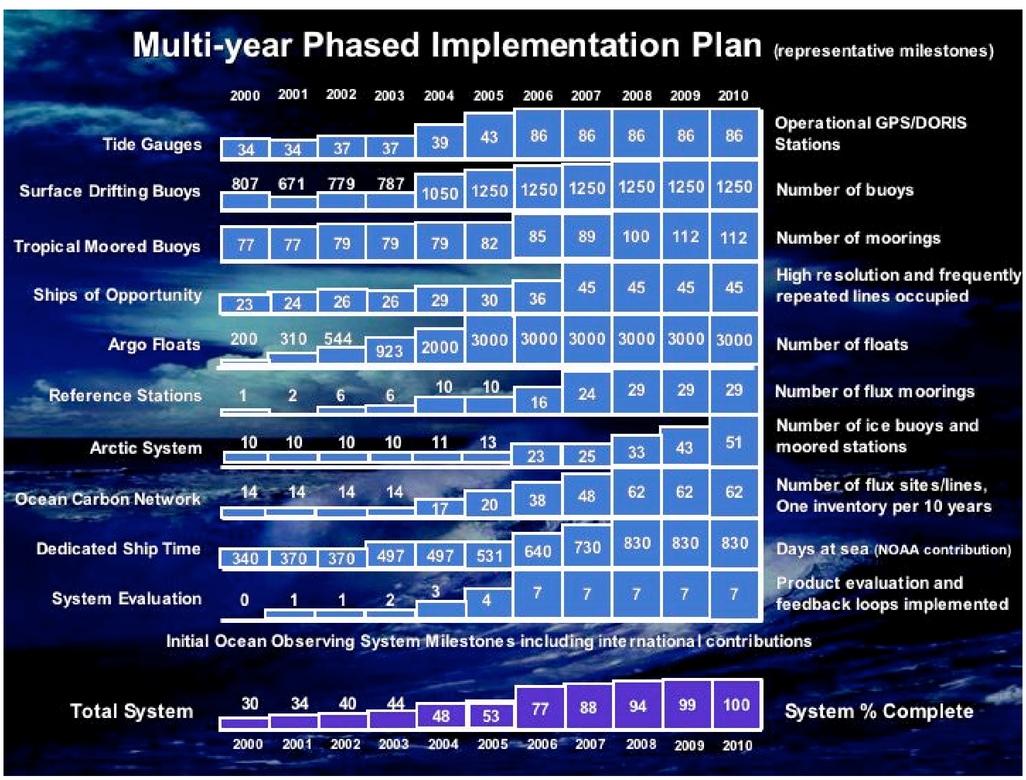

Figure 2

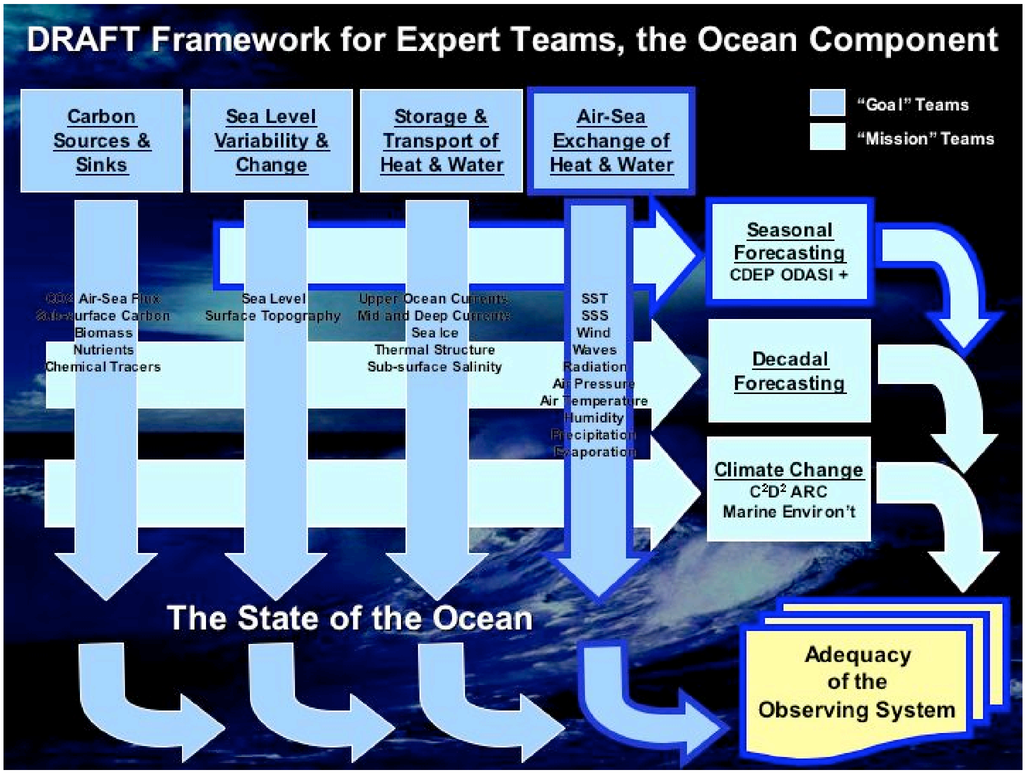

Figure 3

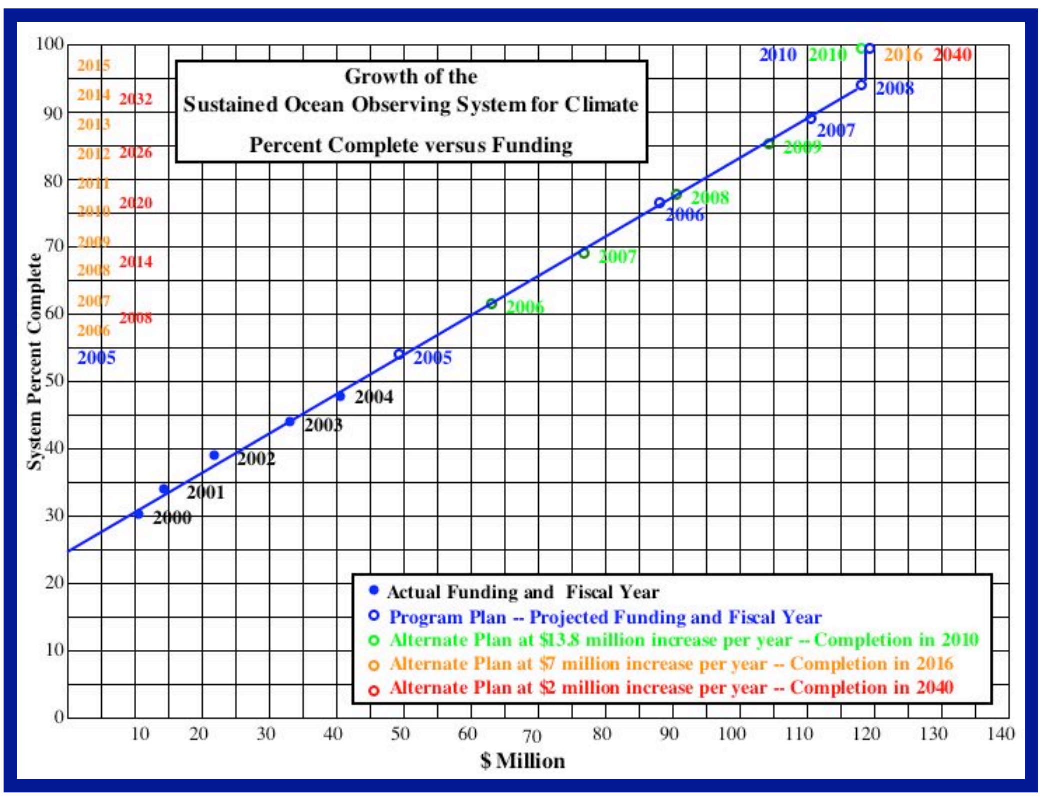

Figure 4

APPENDIX C

Professional Development and Community Service by Scientists Funded by The Office of Climate Observation

Professional Development and Community Service by Scientists funded by the Office of Climate Observation

Community Service (e.g., appointments to science and implementation panels)

Molly Baringer (NOAA/AOML/PHOD)
AGU Ocean Science Secretary, Associate member SCOR panel, Member S2O2 panel, Member NOAA/OAR ship time procurement procedure review panel, Associate Member IAPSO/SCOR Working Group 121 on Ocean Mixing.

Nicolas R. Bates (Bermuda Biological Station for Research, Inc.)
CARINA Steering Committee Member; International Advisory Member of the European CarboOcean project.

Mark A. Bourassa (COAPS)
NASA Ocean Vector Winds Science Team.

John Bullister (NOAA/PMEL)
Served on WOCE Data Products Committee.

Steven K. Cook (NOAA/AOML/PHOD)
WMO/IOC Data Buoy Cooperation Panel, GOOS Global Drifter Program, WMO/IOC Ship Observations Team, Chairman – Ship of Opportunity Implementation Panel, Convener - Task Team on VOS Recruitment and Program Promotion, Task Team on VOS Automated Systems, Expert Group on Instrument Testing.

Yeun-Ho Chong Daneshzadeh (NOAA/AOML/PHOD)
WOCE and Beyond Meeting as XBT DAC representative; Global Temperature Salinity Profile Program Committee.

Chris Fairall (NOAA/ETL)
Appointed to chair the WCRP Working Group on Surface Fluxes, Serves on the International Geophysical Union International Climate Dynamics and Meteorology Working Group A (Boundary Layers and Air-Sea Interaction).

Richard A. Feely (NOAA/PMEL)
Co-chair Repeat Hydrography CO_2/tracer Program Oversight Committee; International Ocean Carbon Coordination Project, Paris, Jan 2003; International Pacific CLIVAR Panel; Carbon Cycle Science Program Science Steering Group; Team Member of the European CarboOcean; Member of PICES Working Group 17.

Silvia Garzoli (NOAA/AOML/PHOD)
Appointed to Climate OAR Board/Team; Appointed to the NOAA Experts team to provide NOAA input to the U.S. interagency process developing a U.S. Plan on Earth Observations and the U.S. position for the ad hoc intergovernmental Group on Earth Observations.

Gregory Johnson (NOAA/PMEL)
Member, 2002-Present, U.S. CLIVAR/CO_2 Repeat Hydrography Oversight Committee; Associate Editor, 2000-Present, Journal of Physical Oceanography; Member, Organizing Committee for WOCE and Beyond Conference, San Antonio, November 2002.

Michael J. McPhaden (NOAA/PMEL)
President of the Ocean Sciences Section of the American Geophysical Union; Serves on the International CLIVAR Pacific and Indian Ocean Panels; Member of the JCOMM Observations Coordination Group; Chairs the Tropical Moored Buoy Implementation Panel (TIP) which is an action group of the Data Buoy Cooperation Panel (DBCP); Member of the OOPC/CLIVAR Global Eulerian Observatories Working Group; Served on the PIRATA Scientific Steering Group; Member of the Bulletin of the American Meteorological Society editorial board.

Frank J. Millero (University of Miami)
Committees - Oversight Committee for the Repeat Hydrography Program (CLIVAR, CO_2/SCC) 2002-2003; Board of Visitors, 2003; Clair C. Patterson Award Committee, Chair, 2003. Honors - Carnegie Mellon 2003 Alumni Distinguished Achievement Award.

Chris Sabine (NOAA/PMEL)
International CLIVAR/CLIC Southern Ocean Panel; Scientific Steering Committee for IGBP/IHDP/WCRP Global Carbon Project; International Ocean Carbon Coordination Project (IOCCP); Working Group for the Implementation of the North American Carbon Program (NACP); Member of CARbon dioxide IN the Atlantic (CARINA); Member of PICES Working Group 17.

Shawn R. Smith (COAPS)
Ocean.US IOOS Expert Team on Archival and Access, Provides Pacific FSU wind fields each month for publication in the NOAA/CDC Climate Diagnostics Bulletin.

Rik Wanninkhof (NOAA/AOML)
International Ocean Carbon Coordination Project, Paris, Jan 2003; Carbon Cycle Science Program Science Steering Group; Team Member of the European CarboOcean, Seakeepers Society Instrument Advisory Board.

Robert Weller (WHOI)
AGU, OS Section Executive Committee, Chair OS Section Awards Committee; Member, AGU-ALSO joint committee for Ocean Sciences meetings; Member, International CLIVAR SSG; Member; International CLIVAR Pacific Implementation Panel; Member CLIVAR VAMOS EPIC Science Team; Co-chair, U. S. CLIVAR Science Steering Committee; Member, UNESCO/IOC Ocean Observations Panel for Climate (OOPC); Member, UNESCO/WMO GOOS Capacity Building Panel; Member, NRC Committee on the Implementation of a Seafloor Observatory Network for Oceanographic Research, 2002-2003; Member, NRC Environmental Satellite Data Utilization Committee, 2002-present; Member, NRC Committee to Review the Climate Change Strategic Plan (CCSP), starting 2002; Member, CORE Ocean Observatories Steering Committee (OOSC); Member, DEOS (Dynamics of Earth Ocean Systems) Executive Committee; Member, NSF Scientific Cabled Observatory for Time Series Committee; NOAA: Climate Observing System Council, Climate Council; Co-chair, International Time Series Science Team; CCSP Interim Ocean Carbon Implementation Group, 2002-present; Chair of the NOAA Joint Institute Directors, starting July 2003; Member, NOAA Senior Research Council, starting July 2003.

List of conferences/workshops presented at/attended

Molly Baringer (NOAA/AOML/PhOD)
Tropical Atlantic Workshop, Miami, March 2003; NOAA/OGP Principle Investigators Meeting, May 2003; AGU fall planning meeting, San Francisco, CA June 2003; AGU fall planning meeting, Washington, DC, Sep 2003; CIMAS review presentation, Jan 2003.

Nicolas R. Bates (Bermuda Biological Station for Research, Inc.)
Meetings: OCEANS (now IMBER) and International Ocean Carbon Coordination Project, Paris, January 2003; CARINA (Carbon in the North Atlantic) meeting, Gran Canaria, March 2003 (presentation of U.S. NOAA VOS CO_2 network plans); CLIVAR North Atlantic Planning meeting, Villefranche-sur-Mer, April 2003 (presentation of U.S. NOAA VOS CO_2 network plans); JGOFS final meeting Washington DC, May 2003; JGOFS SMP Meeting, WHOI, June 2003.

Center for Ocean-Atmospheric Prediction Studies (COAPS)
Meeting attendance/participation:
Bourassa, M. A., and J. J. O'Brien, 2003: Fine resolution satellite-based winds for episodic events. Oceans 2003 Marine Technology and Ocean Science Conference, Sept. San Diego, CA; Bourassa, M. A., J. J. O'Brien, and S. R. Smith, 2003: SeaWinds validation through comparison to research vessel observations. ADEOS-II/SeaWinds Calibration/Validation meeting, Oct. Pasadena, CA; Bourassa, M. A., S. L. Morey, J. J. O'Brien, J. Zavala-Hidalgo, 2003: Satellite-based Episodic Events for Meteorology and Ocean Forcing. Symposium on Upper Ocean Circulation and Air-Sea Interaction, May, Tallahassee, FL; Lagerloef, G. S. E., R. B. Lukas, F. Bonjean, J. T. Gunn, G. T. Mitchum, M. Bourassa, T. Busalacchi: 2003, El Nino tropical Pacific Ocean surface current and temperature evolution in 2002 and outlook for La Nina in early 2003, IUGG 2003, July, Sapporo, Japan; Bourassa, M. A., J. J. O'Brien, S. R. Smith, and R. Romero, 2002: A new FSU wind and flux climatology. Abstracts from WOCE and Beyond, San Antonio, TX, 162; Bourassa, M. A., and J. J. O'Brien, 2003: Fine resolution satellite-based winds for episodic events. Oceans 2003 Marine Technology and Ocean Science Conference, Sept. San Diego, CA; O'Brien, J. J., M. A. Bourassa, and S. L. Morey, 2003: Excellent Winds from Space – SeaWinds for Ocean Models. High Resolution Marine Meteorology Workshop, March, Tallahassee, FL; O'Brien, J. J., M. A. Bourassa, X. Jia, S. L. Morey, B. Subramanyan, and J. Zavala, 2003: Gulf of Mexico Currents Driven by High-Resolution Gridded QSCAT Winds. Ocean Vector Wind Science Team Meeting, Jan. Oxnard, CA; Smith, Co-Chair, Workshop on High-Resolution Marine Meteorology, Tallahassee, FL, March 2003; Smith, Presenter, Climate Observation Program Workshop, Silver Spring, MD, May 2003; Smith, Attendee, NESDIS Data Users' Workshop, Boulder, CO, June 2003 Finally, on 3-5 March 2003, COAPS hosted a "Workshop on High-Resolution Marine Meteorology" (Smith 2003, Smith et al. 2003a); Bourassa, M. A., 2003: Application of R/V data to satellite calibration/validation. High Resolution Marine Meteorology Workshop, March, Tallahassee, FL; Bourassa, M. A., O'Brien, J. J., R. Romero, and S. R. Smith, 2003: A New Objective FSU Winds Climatology. The Oceanographic Society Meeting, June, New Orleans, LA.

Luca Centurioni (SIO)
Argo Workshop, Tokyo, Japan, November 2003; DBCP-19, Rio de Janeiro, Brazil, October 2003; The EGS/AGU Meeting, Nice, France, April 2003.

Steven K. Cook (NOAA/AOML/PhOD)
Workshop on High Resolution Marine Meteorology; WMO/IOC Data Buoy Cooperation Panel; WMO/IOC Ship Observations Team; WMO/IOC Ship of Opportunity Implementation Panel (Chaired); NOAA Marine and Aviation Operations Conference.

Yeun-Ho Chong Daneshzadeh (NOAA/AOML/PhOD)
WOCE and Beyond Meeting as XBT DAC representative; Global Temperature Salinity Profile Program Committee.

Craig Engler (NOAA/AOML/PhOD)
WMO/IOC Data Buoy Cooperation Panel.

Chris W. Fairall (NOAA/ETL)
NOAA 27th Annual Climate Diagnostics and Prediction Workshop, NOAA-OGP, Fairfax, VA, 21-25 October 2002; Twelfth Conference on Interactions of the Sea and Atmosphere, AMS, Long Beach CA, 10-14 February 2003 - Papers presented: 1) Bulk parameterization of air-sea fluxes: Updates and verification of the COARE algorithm (Invited), 2) The air-sea moisture transfer coefficient for wind speeds from 0 to 20 m/s; Workshop on High-Resolution Marine Meteorology, NOAA, Florida State University, Tallahassee, FL, 3-5 March 2003 - Paper presented: Shipboard monitoring of stratocumulus cloud properties in the PACS region; Sixth Annual Meeting of the WCRP/CLIVAR VAMOS Panel, NOAA-OGP, Miami, FL, 23-27 April, 2003; NOAA Intra-Seasonal to Interannual Prediction Program Workshop, NOAA-OGP, Silver Spring, MD, 12-13 August 2003.

Richard A. Feely (NOAA/PMEL)
International Ocean Carbon Coordination Project Invited Talk, Jan 2003; Climate Observations and Services PI Meeting, May 2003; International JGOFS North Pacific Synthesis Group Invited talk, November, 2003.

Paul Freitag (NOAA/PMEL)
TAO Project Manager representing the TAO project office on the DBCP; Reported on TAO activities at the annual DBCP workshop held in Martinique in October 2002; Reported on the details of TAO real-time and delayed mode data sets at the Workshop on High-Resolution Marine Meteorology held in Tallahassee, Florida in March 2003.

Silvia Garzoli (NOAA/AOML/PHOD)
CLIVAR/OOPC/IAI Workshop on the South Atlantic Climate Observing System, February 6 – 8, 2003 Hotel Portogalo, Angra dos Reis - Brazil (invited presentation); The first meeting of the Aquarius/SAC-D Science Team, Hotel Costa Galana, Mar del Plata, Argentina, March 18-20, 2003 (invited presentation).

Gustavo Goni (NOAA/AOML/PHOD)
CLIVAR/OOPC/IAI Workshop, Angra dos Reis, Rio de Janeiro, Brazil, February 2003; Tropical Atlantic Workshop, Miami, March 2003; IUGG Meeting, Sapporo, Japan, July 2003.

Dave Hosom (WHOI)
High Resolution Marine Meteorology Workshop, Tallahassee, March 2003; The Climate Observation Program Workshop, May 2003.

Elizabeth Johns (NOAA/AOML/PHOD)
SEACOOS meeting, Jacksonville, FL, June 2003.

Gregory Johnson (NOAA/PMEL)
WOCE and Beyond Conference, San Antonio, November 2002. (Author or co-author on 5 presentations.)

Rick Lumpkin (CIMAS/AOML)
Lagrangian Analysis and Prediction of Coastal and Ocean Dynamics, "Estimating means and seasonal variations from surface drifter observations in the Atlantic Ocean", Key Largo, FL, 12-16 December 2002.

Mike McPhaden (NOAA/PMEL)
Participated in several meetings including the IOGOOS meeting in Mauritius (November 2002), the PIRATA SSG (February 2003 in Brazil), the NOAA Climate Observations Workshop (May 2003, Washington, DC), the CLIVAR SSG-10 meeting (Victoria, BC, May 2003), the PUMP Workshop (Boulder, May 2003), and the OOPC meeting (Ottawa, Ontario, September 2003). Contributed to drafting the OOPC/CLIVAR GEO Working Group white paper and visited Peru in October 2003 to provide advice to the government on the evolving El Niño.

Frank J. Millero (University of Miami)
Meetings - Invited lecturer, "United States Carbon Dioxide Studies in the Atlantic," Carbon Dioxide in the Atlantic Ocean 2nd CARINA General Meeting and Open Science Conference, February 26 – March 1, 2003, Maspalomas, Gran Canaria, Spain; Invited lecturer, "The speciation of metals in natural waters," Annual Congress of the GTC and of the XIV Italian-Spanish Congress on the Thermodynamics of Metal Complexes, Villa Orlandi, Capri, Italy, June 2003; Invited lecturer, "The CO_2 system in the oceans," Old Dominion University, September, 2003.

Calvin W. Mordy (JISAO/UW)
WOCE and Beyond, San Antonio, TX, November 18-22, 2002; The nutrient workshop at Scripps Institute of Oceanography, March 5-7, 2002.

Mark Morrissey (University of Oklahoma)
Presented a report at the 15th annual Pacific Meteorological Director's meeting in Nadi, Fiji during March 2002; Presented results of this year's work at the 15th meeting of the Working Group on Data Management for the GPCP in Tokyo, Japan during May 2002; Work presented at the 1st Meeting of the International Precipitation Working Group held in Madrid, Spain in September 2002; Presented an update associated with the SPaRCE program at an invited talk at the National Council for Geographic Education Annual Meeting, Philadelphia, October.

Peter Niiler (SIO)
DBCP-19, Rio de Janeiro, Brazil; October 2003; NASA/Scatterometer Workshop, Pasadena, CA, September 2003; NOAA Workshop on "Ocean Climate Observations", Silver Spring, MD, June 2003; The Jet Propulsion Laboratory, Invited lecture on: "How surface circulation determines the absolute sea level of the oceans", May 2003; Scripps Institution of Oceanography, Lecture on: "How surface circulation determines the absolute sea level of the oceans", May 2003; The EGS/AGU Meeting; Nice, France, April 2003.

Mayra Pazos (NOAA/AOML/PHOD)
WOCE and Beyond Meeting as GDC DAC representative; WMO/IOC Data Buoy Cooperation Panel.

Richard W. Reynolds (NCDC)
GCOS SST/Sea-Ice Working Group - Presented at third meeting of the GODAE High Resolution (SST) Pilot Project meeting, Frascati, Italy, December 2-4, 2002; Analyzing sea surface temperatures for climate using ship, buoy and satellite data - Presented at the Satellites in Our Everyday World Workshop, North Carolina State University, Raleigh, NC,

March 13, 2003; GCOS SST/Sea-Ice Working Group progress - Presented at 8th Ocean Observations Panel for Climate Meeting, Ottawa, Canada, September 3-6, 2003; SST analysis options and methods for estimating bias and other errors in satellite input data sets and final SST products - Presented at fourth meeting of the GODAE High Resolution (SST) Pilot Project meeting, Pasadena, CA, September 22-26, 2003; A buoy need network for improved SSTs - Presented at the Climate Observing System Council's Climate Observation Program Workshop in Silver Spring, May 13-15, 2003; An operational buoy need network for climate SST - Presented at the International Union of Geodesy and Geophysics XXIII General Assembly, Sapporo, Japan, June 30 - July 11, 2003.

Christopher Sabine (NOAA/PMEL)
International Ocean Carbon Coordination Project, Paris, Jan 2003; Global Carbon Project Scientific Steering Committee, 2002; US CLIVAR Scientific Steering Committee; SCOPE/GCP Rapid Assessment of the Carbon Cycle, Brazil, 2003.

William Scuba (SIO)
DBCP-19, Rio de Janeiro, Brazil; October 2003.

University of Hawaii Sea Level Center (UH)
Meeting attendance/participation:
Attended the Western Pacific Geophysics Meeting in Wellington, New Zealand, chaired a session, and presented three papers, one jointly with PMEL and NODC; Late 2002 - served on the National Oceanographic Partnership Program Ocean.US Applications and Products Expert Team; Fall 2002, utilizing GLOSS resources, visited the Diretoria de Hidrografia e Navegacao da Marinha of Brazil; Participated in the NOAA sponsored Regional workshop on Potential Applications of Ocean Observations for the Pacific Region in Nadi, Fiji - presented on sea level rise at Tuvalu and participated in various working groups; Served at the concurrent meeting of the PacificGOOS Steering Committee; Fall 2002, the UHSLC conducted an inventory of its observation systems as part of the NOAA Observing Systems Architecture (NOSA) via the NOAA Forge online system; October 2002 - participated in the Jason-1 Science Working Team meeting in New Orleans and presented a poster on our GPS@TG network measurements; November 2002 - attended the WOCE & Beyond Conference in San Antonio; March 2003 - participated in a round table of Federal Hazard Mitigation Partners in the Pacific Islands in Honolulu, where we presented an update on extreme sea level events in the Pacific region; April 2003, utilizing GLOSS resources, UHSLC JASL coordinator, Pat Caldwell was one of three faculty in the GLOSS Training Course held at the Servicio de Hidrografia y Oceanografia de la Armada in Chile; Visited the Dirreccion de Hidrografia y Navegacion of Peru; represented the GLOSS at the International Hydrographic Organization Committee on Tides conference held in Lima on April 23, 2003; May 2003 - participated in the Climate Observation Program Workshop at Silver Spring, Maryland; July 2003 - presented a paper on decadal sea level in the Pacific at the IUGG in Sapporo, Japan.

Rik Wanninkhof (NOAA/AOML)
International Ocean Carbon Coordination Project, Paris, Jan 2003; High Resolution Marine Meteorology Workshop, Tallahassee, March 2003; JGOFS final meeting Washington DC, May 2003; Climate Observations and Services PI Meeting, Washington DC May 2003.

Robert Weller (WHOI)
NOAA Constituent Meeting, Boston, September 2002; Climate briefing for Adm. Lautenbacher, Wash DC, Sept 2002; DEOS Steering Committee, Oct 2002; State Department workshop on global oceanography, Wash DC, Nov 2002; Fall AGU, Dec 2002; NRC committee, Seafloor Observatories, Irvine, CA Dec 2002; CLIVAR SSC, San Diego, Jan 2003; NRC Committee, CCSP review, Irvine, Jan 2003; Aha Hulikoa Workshop, Hawaii, Jan 2003;

Moorings Working Group, Ocean Observatories Initiative, Santa Fe, Feb 2003; Annual AMS Meeting, Long Beach, Feb 2003; NRC Committee, Seafloor Observatories, Wash DC, Feb 2003; Pacific Decadal Variability Workshop, Wash DC, Feb 2003; High Resolution Marine Meteorology Workshop, Tallahassee, March 2003; NRC Committee, Environmental Satellite Data Utilization, Wash DC, March 2003; VAMOS Science Panel, VEPIC workshop, Miami, April 2003; International CLIVAR Science Steering Group, Victoria, BC, May 2003; NOAA Climate Observing System Council, Wash DC, May 2003; Pacific upwelling and mixing program (PUMP) workshop, Boulder, May 2003; DEOS Steering Committee, New Orleans, June 2003; NRC Committee, Environ. Satellite Data Utilization, Madison, WI, June 2003; RV Revelle precruise planning meeting, San Diego, June 2003; NOAA Senior Research Council, Boulder, July 2003; NOAA Interseasonal to Interannual Prediction workshop, Wash DC, August 2003; Climate Analysis Workshop, NCAR, Boulder, August 2003; NRC Committee, CCSP review, Wash DC, August 2003; Ocean Observations Panel for Climate (OOPC), Ottawa, Sept 2003; NRC Committee, Environmental Satellite Data Utilization, Sept 2003; PACS/EPIC Workshops, NCAR, Sept 2003; DEOS Steering Committee, San Francisco, Oct 2003; NRC Committee to Review CCSP, Irvine, CA, Oct 2003; Site Review of NOAA Joint Institute at U. Oklahoma, CIMMS, Oct 2003.

Jia-Zhong Zhang (NOAA/AOML)
The nutrient workshop at Scripps Institute of Oceanography, March 5-7, 2002.

Outreach (e.g., press/media interviews, public lectures)

Molly Baringer (NOAA/AOML/PHOD)
CIMAS review presentation, Jan 2003.

Gustavo Goni (NOAA/AOML/PHOD)
GLOSS Training Course, Valparaiso, Chile, April 2003.

Elizabeth Johns (NOAA/AOML/PHOD)
SEACOOS meeting, Jacksonville FL, June 2003.

WMO/IOC GOOS Center – Voluntary Observing Ship Recruitment
Gave presentations to Maersk-Sealand North America, Maersk Corporate Headquarters, Safmarine Shipping Headquarters.

Mayra Pazos (NOAA/AOML/PHOD)
Gave presentations at elementary schools

Tropical and sub-tropical Atlantic Surface Drifters Array (NOAA/AOML/PHOD)
Data have been used for educational purposes at the University of Miami and at public school.

Rik Wanninkhof (NOAA/AOML)
Mentored a student intern, Sabate Visconti on the Dade County Advanced Academic Internship Program on project "physical and biological controls on pCO_2 levels in the Caribbean"; hosted a post-doc, Are Olsen sponsored by the Norwegian Research Council working on project, "methods of extrapolating pCO_2 in time and space".

Robert Weller (WHOI)
Gave briefings to school children about Stratus project and mooring hardware while loading RV Revelle in San Diego, Sept 2003; NOAA Teacher-at-Sea program involved in November 2003 cruise with a teacher from San Marcos, CA and a teacher from Arica, Chile on board.

APPENDIX D

Request for Annual Progress Report
and
Report Format

Request for Annual Progress Report

29 August 2003

Dear Climate Observationalists:

Thank you for your participation in the Climate Observation Program Workshop 13-15 May in Silver Spring. It was a successful meeting and provided good direction for the continued development of a truly sustained global climate observing system. We plan to hold the Second Annual Climate Observation Program Review 19-24 April 2004. Please place this date on next year's calendar.

Based on your input during the workshop, we are requesting an annual progress report from you to document individual project outcomes, help identify system needs, and help establish the foundation for future program growth. As discussed in May, your reports will provide a major part of the information needed for our Program's *Annual Report on the State of the Ocean and the Observing System for Climate*. This information will also be used to update the Program Plan and the NOSA database.

As we move toward a sustained observing system it is anticipated that, for the established projects, the filing of the annual progress reports will replace the traditional research proposal process. Each project's annual work plan will provide the justification and accountability for funding needed to sustain existing work and/or funding increases needed to accomplish new work.

Your annual progress report should include: 1) a project summary, 2) FY 03 progress, 3) FY 04 work plan, 4) a corresponding FY 04 budget, and 5) "Add Tasks". Attachment 1 is an outline of the reporting guidelines. The guidelines are intended to provide a somewhat standard look and feel across all the projects and to allow the Project Office to extract summary information and system-wide statistics for preparing the *Annual Report*, other system reports, and for answering questions from NOAA management. It is also hoped that, using information from your annual progress reports, the Project Office will be able to accomplish a significant amount of the routine updating of the NOAA Observing System Architecture (NOSA) database in order to relieve the labs and centers of that administrative burden.

If your lab/center is implementing more than one project, please evolve toward a single annual report for each network. For example, AOML would collect all of its SOOP projects into a single report. Within each report, however, identify the various components as separate Tasks, if appropriate. For example, AOML might have separate Tasks identified for implementing the North Atlantic HRX lines, the South Atlantic HRX lines, and the Pacific broadcast XBT lines. The tasks should be based on the work plans under which you are presently operating so that scientific rationale and review can be traced back through the Project Office files.
The Project Office's *Annual Report* will summarize progress by "network" (as per the JCOMM panels and per our Program Plan). If your lab/center works across several networks, please report these separately. For example, AOML's GOOS Center would file separate annual reports for the SOOP work and for the Global Drifter Program work. It may be difficult to break out personnel costs, etc. between projects if the same people work on more than one, but please provide your best estimate of the separation.

For FY 04, it is the intent of the Climate Observation Program to sustain existing projects at the FY 03 level of funding (depending on the appropriation/allocation process, of course).

The budget sheet and cover sheet of your annual report should reflect that "base" budget level for FY 04 work.

The climate observing system must be stable but not static. Project managers should evolve their work within their "base" budget to achieve maximum effectiveness and efficiency as scientific understanding and technology advance. Any significant changes, however, must be accomplished in accordance with the Ten Climate Monitoring Principles and in cooperation with the international implementation panels, in particular the JCOMM panels. The Ten Principles are listed in the Appendix of the Program Plan, which is included with this message (Attachment 2) for your reference.

In addition to your base project Tasks, please include "Add Tasks" with your report. The Add Tasks should outline incremental expansions and improvements that you would like to accomplish if additional funding becomes available. Include a cost estimate for each Add Task. When/if new funding becomes available, the Project Office will evaluate the Add Task requests against Program priorities. For selected Add Tasks we will ask for a detailed budget sheet to document a supplement to your annual work plan. In most cases, the selected Add Tasks will then become part of the project's base funding for following years.

Add Tasks that are obvious advancements of the Program Plan can be brief and need little scientific justification. Add Tasks that are not so obvious should include scientific rationale and implementation strategy at about the same level of detail as a standard letter of intent – i.e., two pages. Cite workshops, science and/or implementation panels, and/or program steering group reports recommending the advancements proposed in each Add Task.

Budget planning values for FY 04 are attached (Attachment 3). This plan was used to document NOAA's request for a FY 04 budget increase. The values shown are "before taxes;" in the best case scenario the Program will see about 89%. You should use this as guidance in creating your Add Tasks. Of course the Federal appropriation and NOAA allocations seldom equate to the budget planning. So, if possible, develop several modestly priced Add Tasks that could build your network incrementally according to actual funding availability. Please list your Add Tasks in your recommended priority order.

The FY 04 budget planning represented in the attachment was put in place two years ago. It is subject to modification. If we are serious about building an observing system that is responsive to our customers' requirements -- and we are serious about that -- we must be prepared to adjust course according to customer feedback. The Project Office will constantly review user input and may modify planning and priorities as we move forward; so the ratios of new funding applied to the networks may vary from the attached FY 04 plan. You should use it as guidance but should not be constrained by it.

At the Program Workshop in May, NCEP identified three high priority areas for observing system evolution in support of seasonal forecasting (see Attachment 4). Where practical, explain how you can utilize your base capabilities to begin addressing these requirements, and/or target these areas with appropriate Add Tasks.

The individual project reports as well as the Project Office's *Annual Report* will be subject to peer review and to programmatic review by the Climate Observing System Council. The Program Plan and our overall Program performance are also subject to continual review by NOAA's Programming, Planning, and Budgeting System.

Please submit your annual report by 15 October so that we can move money to you as soon as possible in the fiscal year. We intend to move funding to the universities and joint institutes as well as to the labs/centers early in the year even though the official continuation dates of most joint institute cooperative agreements is 1 July.

METHOD OF SUBMISSION

Your progress report should be submitted electronically by 15 October to climate.observation@noaa.gov. Follow with hard copy to:

NOAA Office of Climate Observation
1100 Wayne Avenue
Silver Spring MD 20910
1-301-427-2089

Thank you for your continued dedication to building the sustained ocean observing system for climate.

Sincerely,

Diane Stanitski
Associate Program Manager
Climate Observation

Report Format

Please include the following information, where applicable, in your annual progress reports. Be as concise and comprehensive as possible and include the full name of all projects and acronyms used. Graphics are encouraged as a means to present your status and findings. Please provide a map(s) indicating locations instrumented or analyzed.

COVER PAGE

- Project title
- Project period – make this FY 03, if possible (Oct 1, 2002 – Sept 30, 2003)
- Project Manager(s) – name, title, affiliation, address, phone, email
- Primary contact person for finance – name, phone, email
- Signature for person(s) responsible/accountable, e.g., Lab Director

PROJECT SUMMARY

- General overview of the project, including brief scientific rationale
- Statement about how your project addresses NOAA's Program Plan for *Building a Sustained Ocean Observing System for Climate*
- Statement about how your project is managed in cooperation with the international implementation panels, in particular the JCOMM panels
- Responsible institutions for all aspects of project
- Project web site URL and pertinent web sites for your project and associated projects
- Interagency and international partnerships
- Statement that your project is managed in accordance with the Ten Climate Monitoring Principles (reference attached Program Plan)

FY 2003 PROGRESS

- Instrument/platform acquisitions for fiscal year and where equipment was deployed
- Number of deployments – compare to the previous year
- Percentage data return for fiscal year and 'lifetime' statistics – compare to the previous year
- Measurements taken, where data are stored, data distribution, availability and access to data
- How data are currently being used and shared
- Where the data are archived
- Anticipated and unanticipated project costs
- Problems encountered
- Logical considerations (e.g., ship time utilized)
- Research highlights
- List of all refereed publications, technical reports, and meeting proceedings related to your project (include a copy of one or two refereed papers in your Appendix representative of your project that could be included in the Annual Report and send one paper copy of ALL publications, reports, etc. related to the project directly to the OCO)
- Community service (e.g., appointments to science and implementation panels)
- List of conferences/workshops presented at/attended
- Outreach (e.g., press/media interviews, public lectures)

FY 2004 PLANS

Please include the following information, if applicable:

- Anticipated requirements to maintain the network at status quo
- Logistics requirements (e.g., ship time)
- New data collection methods

- Expected scientific results

FY 2004 BUDGET

- Show Program funding requirements
- Show non-Program support for the observing system (e.g., PI salary)
- Identify how much of your total budget goes toward: a) operations, b) data management, and c) R & D
- Identify how many FTEs that Program funding supports – a) Federal FTEs, and b) non-Federal FTEs.
- Identify how many FTEs dedicated to the project are not funded by the Program

ADD TASKS

- Rationale
- Proposed work
- Procurements needed
- Additional personnel needed
- Cost estimate

APPENDICES

- Copy of representative publications
- A bibliography of all papers published and in press during the last fiscal year, including references to papers using data accessed through your project.

THE 10 CLIMATE MONITORING PRINCIPLES

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.
2. A suitable period of overlap for new and old observing systems is required.
3. The details and history of local conditions, instruments, operating procedures, data processing algorithms, and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.
4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.
5. Consideration of the needs for environmental and climate-monitoring products and assessments, such IPCC assessments, should be integrated into national, regional, and global observing priorities.
6. Operation of historically uninterrupted stations and observing systems should be maintained.
7. High priority for additional observations should be focused on data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.
8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators, and instrument engineers at the outset of system design and implementation.
9. The conversion of research observing systems to long-term operations in a carefully planned manner should be promoted.
10. Data management systems that facilitate access, use, and interpretation of data and products should be included as essential elements of climate monitoring systems.

APPENDIX E

Contributors and Reviewers: Annual Report

Contributors and Reviewers

Executive Summary – *Diane Stanitski, NOAA/OGP, Silver Spring, Maryland*

Chapter 1: The Role of the Ocean in Climate – *Kevin Trenberth, UCAR, Boulder, Colorado*

Chapter 2: The State of the Ocean
2.1 Global sea level rise – *Laury Miller and Bruce Douglas, NOAA/NESDIS, Silver Spring, Maryland; Robert Cheney, Florida International University, Miami, Florida*
2.2 Observing the global ocean carbon cycle – *Rik Wanninkhof, Atlantic Oceanographic and Marine Laboratory, Miami, Florida; Richard Feely, Pacific Marine Environmental Laboratory, Seattle, Washington*
2.3 In situ data requirements for recent situ sea surface temperature analyses – *Richard Reynolds, National Climatic Data Center, Asheville, North Carolina*
2.4 Surface currents to identify significant patterns of climate variability – *Peter Niiler, Scripps Oceanographic Institution, California; Nikolai Maximenko, International Pacific Research Center, Honolulu, Hawaii*
2.5 Sea surface pressure – *Ed Harrison, Pacific Marine Environmental Laboratory, Seattle, Washington; Authors of the Second Report on the Adequacy of the Global Observing Systems for Climate*
2.6 Air-sea exchange of heat, fresh water, momentum – *Robert Weller, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts*
2.7 El Niño and heat content variations – *Michael McPhaden, Pacific Marine Environmental Laboratory, Seattle, Washington*

Chapter 3: The State of the Observing System
There were many contributors to each FY 2003 progress report and FY 2004 planning report; please refer to authors identified in Chapter 3 under report titles.

Chapter 4: The State of the Science
Contributions were made by the authors of each bibliographic reference.

Reviewers
The following individuals reviewed all or part of this report. Their contributions are much appreciated.

Ed Harrison, *Pacific Marine Environmental Laboratory, Seattle, Washington*
Michael Johnson, *Office of Climate Observation, Silver Spring, Maryland*
Masahiko Kamei, *Office of Climate Observation, Silver Spring, Maryland*
Ed Sarachik, *University of Washington, Seattle, Washington*
Sidney Thurston, *Office of Climate Observation, Silver Spring, Maryland*

This report was made possible through the outstanding contributions of those listed above and throughout this report. It has been a pleasure to work with such motivated and committed individuals. Their vision, dedication, and ingenuity will enable advancement and completion of the global ocean observing system for climate.

APPENDIX F

List of Acronyms

List of Acronyms

ADCP	Acoustic Doppler Current Profiler
AOML	Atlantic Oceanographic and Meteorological Laboratory
APDRC	Asia-Pacific Data Research Center
ARCs	Applied Research Centers
ARPEGE-CLIMAT	Climate Research Project on Small and Large Scales (France)
BMRC	Bureau of Meteorology Research Centre (Australia)
BoM	Bureau of Meteorology (Australia)
BPR	Bottom Pressure Recorder
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency) (Germany)
C&GC	Climate and Global Change
CCRI	Climate Change Research Initiative
CCSP	Climate Change Science Program
CDC	Climate Diagnostics Center
CDP	Climate Data Portal
CFD	Computer Flow Dynamics
CICOR	Cooperative Institute for Climate and Ocean Research
CIMAS	Cooperative Institute for Marine and Atmospheric Studies
CIRES	Cooperative Institute for Research in Environmental Sciences
CLIPS	Climate Information and Prediction Services Project
CLIVAR	CLImate VARiability and Predictability
COLA	Center for Ocean, Land, and Atmosphere Studies
COAPS	Center for Ocean-Atmospheric Prediction Studies
COP	Climate Observation Program
CORC	Consortium on the Ocean’s Role in Climate
COSC	Climate Observing System Council
COSP	Climate Observations and Services
CLIVAR	Climate Variability and Predictability Program
CPC	Climate Prediction Center
CPRDB	Comprehensive Pacific Raingauge Database
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTD	Conductivity, Temperature, Depth
DAC	Data Assembly Center
DBCP	Data Buoy Cooperation Panel
DMC	Drought Monitoring Center
DODS	Distributed Ocean Data System
DWBC	Deep Western Boundary Current
ECCO	Estimating the Circulation and Climate of the Ocean
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Niño-Southern Oscillation
EPIC	Eastern Pacific Investigation of Climate
ERS	Earth Remote-sensing Satellite
ETL	Environmental Technology Laboratory
EVAC	Environmental Verification and Analysis Center
FRX	Frequently Repeated XBT
FSU-COAPS	Florida State University Center for Ocean-Atmosphere Prediction Studies
GAINS	GLOSS Development in the Atlantic and Indian Oceans
GCC	Global Carbon Cycle
GCOS	Global Climate Observing System
GCTE	Global Change and Terrestrial Ecology Program
GCRMN	Global Coral Reef Monitoring Network
GDC	Global Drifter Center

GDP	Global Drifter Program
GEOSAT	Geodesy Satellite
GLOSS	Global Sea Level Observing System
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GPCP	Global Precipitation Climatology Project
GPS	Global Positioning System
GPS@TG	Co-located GPS systems at tide gauge stations
GTS	Global Telecommunications System
GTSPP	Global Temperature-Salinity Profile Program
HRX	High Resolution XBT
HURDAT	Atlantic Basin Hurricane Database
IAI	Inter-American Institute for Global Change Research
IOC	Intergovernmental Oceanographic Commission
IDOE	International Decade of Ocean Exploration
IES	Inverted Echo Sounder
IFREMER	Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploitation of the Sea) (France)
IMET	Improved METeorology
IOOS	Integrated Ocean Observing System
IPRC	International Pacific Research Center
IRD-Brest	L'Institut de recherché pour le developpement – Brest (France)
IRI	International Research Institute for Climate Prediction
ITCZ	Inter-Tropical Convergence Zone
IUGG	International Union of Geodesy and Geophysics
JAMSTEC	Japan Marine Science and Technology Center
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JIMAR	Joint Institute for Marine and Atmospheric Research, University of Hawaii
JIMO	Joint Institute for Marine Observations
JISAO	Joint Institute for the Study of the Atmosphere and Ocean
JMA	Japan Meteorological Agency
JTA	Joint Tariff Agreement
MEDS	Marine Environmental Data Services
MOC	Meridional Overturning Circulation
MOCHA	Meridional Overturning, Circulation and Heat Transport Array
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NEAR-GOOS	North-East Asian Regional GOOS
NERC	National Environmental Research Council
NESDIS	National Environmental Satellite, Data, & Information Service
NGO	Non-Governmental Organization
NIC	National Ice Center
NIH	National Institutes of Health
NMFS	National Marine Fisheries Service
NMHS	National Meteorological and Hydrological Services
NMRI	Naval Medical Research Institute
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOPP	National Ocean Partnership Program
NORPAX	North Pacific Experiment

NOS	NOAA Ocean Service
NOSA	NOAA Observing System Architecture
NSF	National Science Foundation
NWS	National Weather Service
NWS-PR	National Weather Service Pacific Region
NVODS	National Virtual Ocean Data System
OCO	Office of Climate Observation
OGP	Office of Global Programs
OMAO	Office of Marine and Aviation Operations
OOPC	Ocean Observations Panel for Climate
PacificGOOS	Pacific Global Ocean Observing System
PACIS	Pan-American Climate Information System
PDO	Pacific Decadal Oscillation
PEAC	Pacific ENSO Applications Center
PHOD	Physical Oceanography Division
PIES	Pressure Gauge Equipped Inverted Echo Sounder
PMEL	Pacific Marine Environmental Laboratory
PNA	Pacific North America
PNNL	Pacific Northwest National Laboratory
RRP	ENSO Rapid Response Project
RVIB	Research Vessel / Ice Breaker
RSMAS	Rosenstiel School of Marine and Atmospheric Science
SCPP	Seasonal-to-Interannual Climate Prediction Program
SCMI	Southern California Marine Institute
SEACOOS	Southeast Atlantic Coastal Ocean Observing System
SEARCH	Study of Environmental Arctic Change
SEAS	Shipboard Environmental data Acquisition
SI	Seasonal-to-Interannual
SIO-ECPC	Scripps Institution of Oceanography-Experimental Climate Prediction Center
SLP-PAC	Sea Level Program in the Pacific
SOC	Southampton Oceanography Centre
SOOP	Ship-of-Opportunity Program
SOOPIP	Ship-of-Opportunity Implementation Panel
SOI	Southern Oscillation Index
SOT	Ship Observations Team
SPARCE	South Pacific Rainfall Climate Experiment
SRDC	Surface Reference Data Center
SSG	Scientific Steering Group
SSP	Sea Surface Pressure
SST	Sea Surface Temperature
START	Global Change System for Analysis, Research, and Training
SURFRAD	Surface Radiation Budget Network
TAO	Tropical Atmosphere Ocean Array
TOGA	Tropical Oceans-Global Atmosphere Program
TOPEX	Ocean TOPography Experiment
TRMM	Tropical Rainfall Measuring Mission
UHSLC	University of Hawaii Sea Level Center
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
UOTC	Upper Ocean Thermal Center
URI	University of Rhode Island
USIABP	U.S. Interagency Arctic Buoy Program
USGCRP	U.S. Global Change Research Program

UW	University of Washington
VOS	Voluntary Observing Ships
WCRP	World Climate Research Program
WDC-A	World Data Center-A for Oceanography
WHO	World Health Organization
WHOI	Wood's Hole Oceanographic Institution
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WWW	The World Weather Watch of WMO
XBT	Expendable Bathythermograph